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JANUARY
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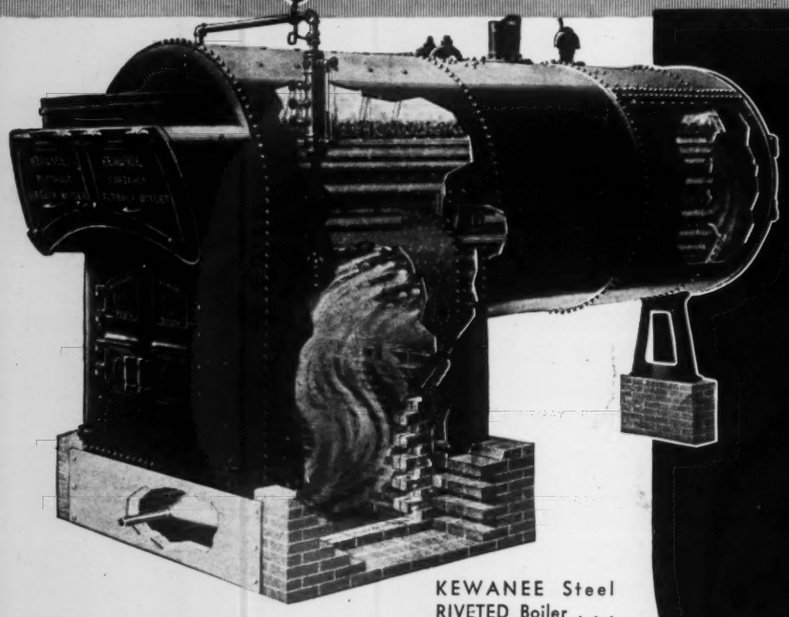

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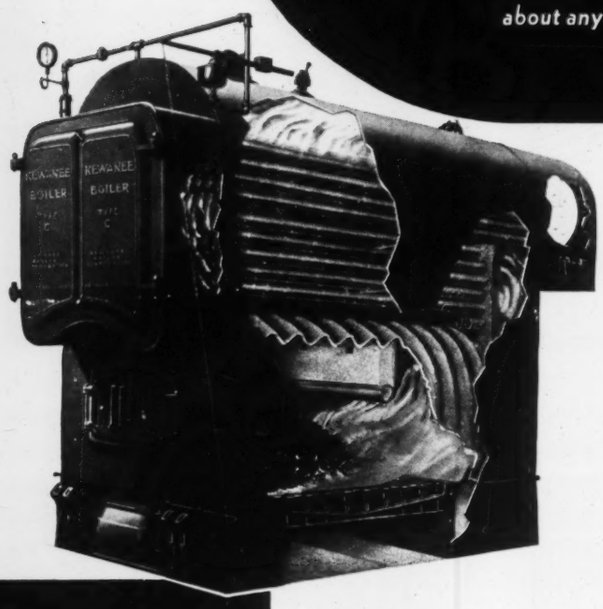

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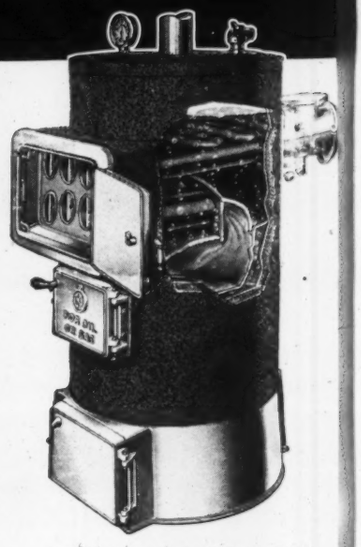

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Engineering

THE EDITOR'S PAGE

JANUARY 27 to 31 is "The Big Week" for the air conditioning, ventilating and heating industry, with the Fourth International Heating and Ventilating Exposition, the annual meeting of the *American Society of Heating and Ventilating Engineers,* and the annual convention of the *National Warm Air Heating and Air Conditioning Association* all in Chicago at that time, at the International Amphitheatre, the Palmer House hotel, and the Stevens hotel, respectively....Complete information about "The Big Week" is given in the tinted stock "Show Section" in this issue, including programs for the meetings, a list of exhibitors and their exhibits, high-lights of the meetings, the exposition and the social activities, as well as a map of the city and a diagram of the exhibit halls....HEATING, PIPING AND AIR CONDITIONING will be glad to furnish any further information at its booths at the exposition (Nos. 322-324) or at its offices in the Tower building, 6 North Michigan Ave., phone State 6916.

Featured this month is the directory section of heating, piping and air conditioning equipment for industry and large buildings, Part 1 being a complete classification of products, Part 2 an alphabetical listing of trade names, showing the product and the manufacturer, and Part 3 the street addresses of manufacturers....Aimed to provide an up-to-date reference working tool for use throughout the year, this information has been carefully compiled for convenient use....As new equipment is announced during the year, it will be described in the columns devoted to "Equipment Developments" in coming issues, may be added to your directory section.

Two names new to our Board of Consulting and Contributing Editors but not to H. P. & A. C. readers appear on our Contents Page this month—L. A. Harding and F. L. Snyder.... Mr. Harding—head of the L. A. Harding Construction Corp., past president of the *A. S. H. V. E.,* co-author of Harding and Willard's "Heating, Ventilating, and Air Conditioning," author of "Steam Power Plant Engineering" and the "Heating and Air Conditioning Manual"—will be remembered as the author of an outstanding series on air conditioning published in H. P. & A. C. last year....No less important have been Mr. Snyder's contributions on the design of modern industrial piping which also were published during 1935, the first article of which appeared just a year ago in our January, 1935, number. ....Mr. Snyder expects to complete another article on this subject for early publication.

L. S. Morse, executive engineer of the York Ice Machinery Corp., was elected president of the *American Society of Refrigerating Engineers* at the annual convention in New York City last month....He became a member of the *A. S. R. E.* in 1909, is also a member of the *A. S. M. E.,* and has served on many technical air conditioning and refrigeration committees. ....As evidence of the fact that the term "air conditioning" is not as new as the general public appears to believe, the *Air Conditioning Manufacturers' Association* cites Stuart W. Cramer's (Parks-Cramer Co.) book on useful information for cotton manufacturers published in 1904 in which air conditioning is referred to at length.

Nineteen hundred and thirty-six is to be a year of golden anniversaries....Westinghouse opened the celebration of its "jubilee year" on January 8 with meetings of employes here and abroad commemorating the granting of the charter to the Westinghouse Electric Co. fifty years ago....The Fitzgibbons Boiler Co. is celebrating the completion of an unbroken half-century in the manufacture and development of steel boilers exclusively; the company was founded in Oswego, N. Y., in 1886 by Patrick Fitzgibbons, was acquired by Homer Addams in 1921....Not its 50th, but its 70th anniversary, is to be celebrated in March by Lafayette College at Easton, Pa....The ceremonies will include conferences and addresses by leaders in engineering.

Graphical symbols to be used in drawings showing piping, pipe fittings and valves, heating and ventilating equipment, heat-power apparatus, plumbing and conventional rivets have been agreed upon by a representative committee under the leadership of the *American Society of Mechanical Engineers* and the *Society for the Promotion of Engineering Education,* and have been approved by the *American Standards Association,* 29 W. 39th St., New York City....As a result of a series of conferences between representatives of various coal and stoker organizations with members of the standardization committee of the *Steel Heating Boiler Institute,* standard specifications covering the design, construction and installation of horizontal steel firebox heating boilers, insofar as furnace volume is concerned for mechanically fired fuels, have been revised to eliminate any differences as to requirements for oil, gas and stoker fired bituminous coal....The final action came when executives of member companies of the *Stoker Manufacturers Association* approved the recommendation of its engineering committee that boiler and stoker setting heights standards adopted and in use by the stoker industry be revised so as to increase heat release requirements approximately 11 per cent in order to place bituminous stoker fired coal on an equal basis with oil and gas.... Air Hygiene Foundation of America, Inc., Pittsburgh, has been formed to conduct investigations of and to stimulate research on problems in the field of air hygiene and to gather and disseminate information relating thereto, and a comprehensive investigation has been begun at Mellon Institute of Industrial Research under the direction of H. B. Meller....Exacting demands by the users of paper and pulp products for materials properly conditioned for use in printing or processing presage far reaching construction activity in these industries in 1936, according to George A. Bryant, Jr., of The Austin Co....The past year has witnessed the application of air conditioning in a number of new warehouses for the storage of paper, and competition for business is bound to result in the extension of air conditioning among other producers of carefully graded stock, according to Mr. Bryant....The Hershey Chocolate Corp., Hershey, Pa., held an "open house" last month to permit public inspection of its new windowless air conditioned, practically indirectly lighted office building. Controlled temperature and humidity and modern lighting make the building independent of outside weather conditions....The roof is unique in that it is a dead level concrete deck where at all times there will be about 2½ in. of water intended to act to some extent as an insulator.

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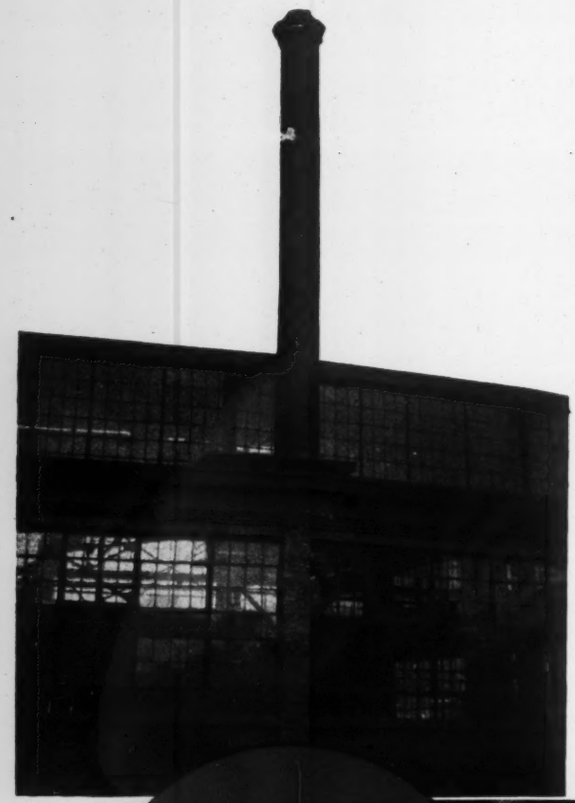
used to combat corrosion from sulphurous locomotive smoke..



That coal smoke from locomotives plays havoc with ordinary ferrous metal was demonstrated by the failure of the smoke exhaust system in the roundhouse of this well-known eastern railroad.

Today, however, the corrosive properties of the smoke have lost much of their hold upon the system, for the five exhaust stacks and the telescopic pipes which carry the smoke from the locomotive stacks to the gathering ducts are Toncan Iron. The gathering ducts also are lined with sheets of this alloy of refined open hearth iron, copper and molybdenum which offers the highest rust-resistance of any ferrous material in its price class.

If rust and corrosion are causing early failure in the sheet metal or piping systems in your plant, here's how to save money in the long run—replace worn out parts with Toncan Iron and specify Toncan Iron for all new installation work. Write for literature.

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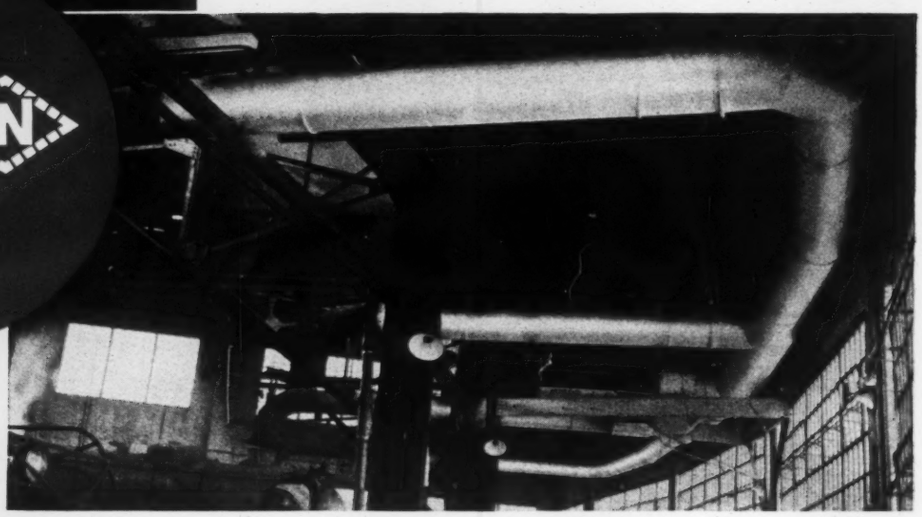

Heating · Piping and Air Conditioning

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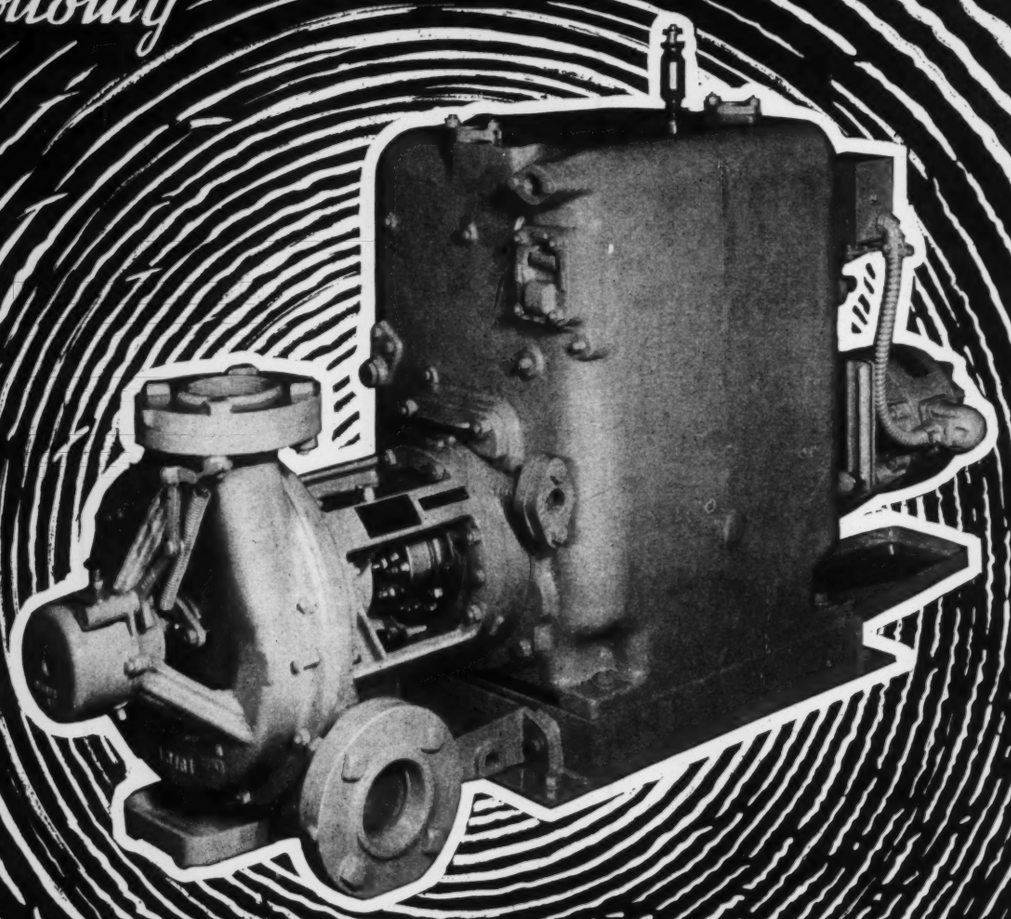

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Heating · Piping and Air Conditioning

Vol. 8, No. 1 • *January, 1936*

AIR CONDITIONING REVIEW

1934 was a "good air conditioning year".....1935 was even better, with an indicated 23 per cent increase over 1934 in number of installations, a 37 per cent increase in connected horsepower.....1936 is expected to be "the best yet"

BASED upon data collected from the utilities serving some 40 cities in various parts of the United States, and summarized in Table 1, there were 2059 air conditioning installations made during the first eleven months of last year as compared with 1675 installations for the entire twelve months of 1934. The connected horsepower for the 1935 jobs totals 63,585 as compared with 46,370 for the 1934 installations. Thus, the percentage increase in number of installations for eleven months of 1935 over twelve months of 1934 was 23 per cent, while the comparable increase in connected horsepower was 37 per cent, indicating that the jobs installed last year were larger than those put in during 1934.

A comparison of these figures with the total installations to December 1, 1935 (including the first eleven months of '35, twelve months of '34, and all installations previous to 1934) demonstrates the rapid growth in the application of air conditioning. On December 1, 1935, there were some 5573 jobs in service in these cities, representing a total connected horsepower of 285,195. Thus, over one-third of the installations now in service were made just last year, and about two-thirds of the installations now in service are less than two years old.

In only three out of thirty-two cities for which information has been tabulated were there fewer installations during the first eleven months of 1935 than during the twelve months of '34, and in two of these cities the 1935 horsepower was larger than the 1934, as the average size of the jobs increased. Three of the thirty-two cities show a decrease in connected horsepower for air conditioning for eleven month of 1935 as compared with twelve months of 1934, one of which is Washington where several very large jobs were installed in government buildings during 1934, Chicago, and New York. Both number of installations and connected horsepower for eleven months of 1935 were slightly under the figures for the entire twelve months of 1934 for New York.

Average size of the 1935 air conditioning installations was greater than that of the 1934 jobs in twenty-eight of the thirty-two cities for which the data are available, the 1935 installations in Washington, D. C., Chicago, New York City, and Rochester, N. Y., decreasing in average size as compared with the 1934 installations. The large government jobs during 1934 raised the average size of the Washington installations for that year, and the decrease in average size for Rochester is probably explained by large industrial installations prior to 1935. Average size of installations is apparently increasing in all but the largest cities. In the largest cities, where air conditioning has been most widely adopted, its advantages are quite naturally becoming more widely appreciated.

It is interesting to analyze the number of installations and connected horsepower for air conditioning by various types of buildings—industrial, commercial and public, and residential. The following tabulation shows the totals for ten cities[1] for which figures are available:

INDUSTRIAL				COMMERCIAL AND PUBLIC				RESIDENTIAL			
1935		TOTAL, DEC. 1, '35		1935		TOTAL, DEC. 1, '35		1935		TOTAL, DEC. 1, '35	
No.	Hp	No.	Hp	No.	Hp	No.	Hp	No.	Hp	No.	Hp
62	3323	264	39,535	685	20,618	1883	103,092	182	346	495	1030

As would be expected, the commercial installations are greatest in number; although the residential installations are more numerous than the industrial jobs, they represent but a fraction of the horsepower accounted for by the industrial installations.

[1]Birmingham, Ala.; Chicago, Ill.; Des Moines, Ia.; Detroit, Mich.; Philadelphia, Pa.; Pittsburgh, Pa.; Richmond, Va.; Rochester, N. Y.; San Antonio, Tex.; and St. Louis, Mo.

Table 1—Number of Air Conditioning Installations and Connected Horsepower for Air Conditioning

Territory	Jan. 1-Nov. 30, 1935 (11 Months)		1934 (12 Months)		Total, Dec. 1, 1935, Including Prior to 1934, 1934, and 11 Months of 1935	
	No.	Hp	No.	Hp	No.	Hp
ALABAMA						
Birmingham	22*	951.6	13*	51.5	46	1797
CALIFORNIA						
Los Angeles	13	448	..*	....	..	....
DIST. OF COLUMBIA						
Washington	158	8484	83	15,868.25	335	29,040.5
FLORIDA						
Miami	42	912.8	18	278.25	64	1819
St. Petersburg	4	18.25	0	0	6	19.75
IDAHO						
Boise	11	40	2	3	37*	208
ILLINOIS						
Chicago	309	5485	244	6662	935	48,832
Rockford	11	142.5	..	....	..	....
INDIANA						
Indianapolis	27	1500	18	510	62	3100
IOWA						
Des Moines	39	422	29	203	93	1300
KENTUCKY						
Louisville	35	713	31	318.5	85	2044
LOUISIANA						
New Orleans	64	2447	33	506	148	7219
MARYLAND						
Baltimore	82	2244	74	1973	228*	7825
MASSACHUSETTS						
Springfield	15	274	..	....	..	....
MICHIGAN						
Consumers Power Co.*	27	220	27	408	62	725
Detroit*	101	6175.1	76*	909.5*	286	17,460.6
MISSISSIPPI						
Jackson	17	98.5	16	38.5	..	....
MISSOURI						
Kansas City*	121	3675.25	152	1020.5	368	7216
St. Louis	184	5335.4	150	1368.4	505	14,200.9
NEBRASKA						
Omaha	45	1133	37	314	100	2766.5
NEW HAMPSHIRE						
Manchester	9	43.75	4	7.75	16	71.45
NEW JERSEY						
Asbury Park*	7	85	6	15	13	100
NEW YORK						
New York City						
Brooklyn	29	2060	26	583	93*	7522*
Manhattan & Bronx.	204	7672	226	8375	694	46,946
Queens	9	161.2	23	267.87	51	4253.12
Rochester	28	665.25	10	555	58	24,947.25
Syracuse	6	211	3	28	14	1282
OKLAHOMA						
Installations on lines of Oklahoma Gas & Electric Co., including air conditioning and air washing installations.	85	1011.87	..	....	244	3571.68
OHIO						
Cincinnati	96	2505	74	1319.75	245	7986.25
Toledo*	24	429	10	51	48	1904
PENNSYLVANIA						
Philadelphia*	111	4735.5	149	2455.8	420	21,980.5
Pittsburgh	94	1367.75	58	432	187	5567.75
Scranton	10	138	5	47	..	....
TENNESSEE						
Installations in Tennessee Electric Power Co.'s territory, including Nashville, Chattanooga, Cleveland, Harriman, Murfreesboro and Columbia, Tenn.	39	511.7	26	146	86	1625.75
TEXAS						
Beaumont	9	243	4	60	16	558
Dallas	75	1205.6	34	382	..	....
El Paso	6	143	3	61	14	411
San Antonio	30	996.5	16	166.5	78	5920
VIRGINIA						
Richmond*	66	1614	32	1287	113	4970
WISCONSIN						
Milwaukee	21	384.55	18	135.53	67	3576.88

Prospects for 1936

Indications are that 1936 will top the record-breaking year of 1935 in volume of air conditioning business. Reports from many sources agree that this year will see more jobs installed than has any previous year.

For instance, the improvement in general business conditions is expected to lead to many installations in the Pittsburgh district this year which were postponed during 1935. Rockford, Ill., is looking forward to a good year. The outlook in the Birmingham territory is "very bright," with the commercial market expected to have the greatest volume and the revival of home building expected to lead to a considerable pick-up in residential air conditioning. Indianapolis expects to double in 1936 the number of installations made in 1935. Kansas City expects 1936 to be a very successful year, particularly if the weather is hot early in the season. Prospects for 1936 "appear good" for Toledo. An increase in horsepower of 50 to 100 per cent during 1936 as compared with 1935, and at least twice as many installations, are expected for Milwaukee. Washington expects to increase in 1936 the horsepower added in 1935 for air conditioning, with neighborhood theaters, department stores, and hotels expected to air condition as well as retail specialty stores, restaurants, etc. Sixteen hundred tons of refrigeration for air conditioning are expected for Miami, based upon prospects known to be interested. The trend of air conditioning in Los Angeles was "very much greater" last year than in 1934 and activity in 1936 is expected to continue in similar manner. In Chicago, 1936 prospects are "very bright" with an unusually large number of installations being figured; Chicago restaurants, private offices, clothing stores, drug stores, undertakers, and beauty parlors should expand considerably in adoption of air conditioning.

To summarize—1934 was a "good air conditioning year" . . . 1935 was a better one . . . and 1936 is expected to be better yet.

[The courtesy of the utility companies serving the cities referred to here in making available the data on number of installations and connected horsepower for air conditioning is gratefully acknowledged.]

Footnotes, Table 1

Baltimore—Total number of contracts; some establishments have two or more installations.

Boise—All installations evaporative cooling jobs except two well water jobs and one evaporative cooling installation arranged for ice melting refrigeration during hot days.

Kansas City, Mo., only; not Kansas City, Kans.—1935 figures include 2000 hp for air conditioning new municipal auditorium.

Detroit—Figures include fan and pump hp (313 hp) for 1935 jobs only; no record kept previous to 1935. Twelve well water installations with 235 hp for pumps and fans are included in the 1935 figures, as is an installation in an automobile body plant for furnishing washed air to paint spray booths and consisting of 1500 hp connected load for pumps and fans. Except for 1935, data covers compressor jobs only (not well water or steam jet). Engine and turbine driven compressors and all motor driven compressors whether served by The Detroit Edison Co. or not are included.

Toledo—1935 jobs were mostly commercial, while 1934 installations were mostly for small offices and residences. One bank job of 268 hp not in operation because of vacancy of banking quarters is included in the data.

Richmond—Figures cover all installations on the system of the Virginia Electric and Power Co.

Philadelphia—Horsepower figures include any additions that may have been made to existing installations; number of jobs shown is for new installations.

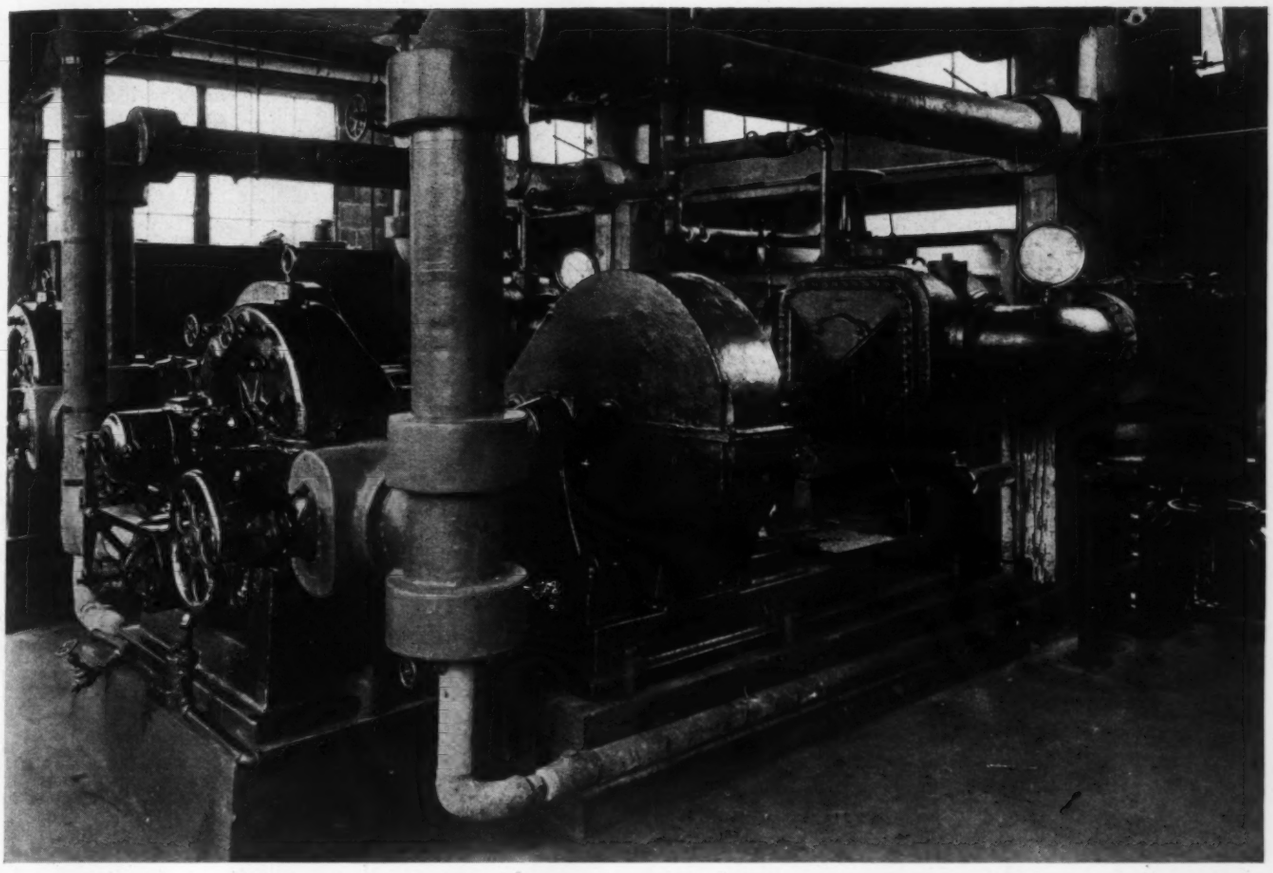
Consumers Power Co.—These figures cover installations in this company's territory, including Battle Creek, Flint, Jackson, Kalamazoo, Pontiac, Grand Rapids, Muskegon, Saginaw, Alma, and Bay City.

New York City (Brooklyn)—Figures for total as of Dec. 1, 1935, will be revised when survey now in progress is completed.

Birmingham.—Figures do not include 5 standby railroad car jobs totalling 50 hp in 1934, and 9 such jobs totalling 90 hp installed in 1935.

Asbury Park, N. J.—Summer air conditioning installations only.

Note:—Blanks indicate no data available.



16 in. steam jacketed turbine driven rotary pump handling 1200 gpm of very heavy crude petroleum

Piping and Pumping Process Materials

By **Lee P. Hynes*** *and* **Charles D. Campbell, Jr.†**

MODERN industry has adopted piping as an important means of transporting many materials formerly considered unsuitable for pumping; these present a number of very interesting and difficult engineering problems.

There are well established general rules for pumping water, light oils, and similar liquids, which may be followed within, of course, certain definite limitations. It is always necessary to avoid turbulence and unduly high pressures. It is also essential that the suction conditions be kept within the laws of physics. For pumping heavy or viscous materials, or those having high melting points or other special characteristics, no such rules apply and each project must be considered individually. It is necessary to check carefully the pipe friction losses. Some change in viscosity or in pipe size may entirely alter the problem—in fact, may prevent a satisfactory operating result.

Some materials require heating to render them fluid enough for pumping, while a few require refrigeration before they can be pumped. The latter are materials so charged with volatiles that unless they are kept at low temperature they will yield enough gas to kill the pump suction. Thus, many intricate problems in thermodynamics as well as mechanics arise.

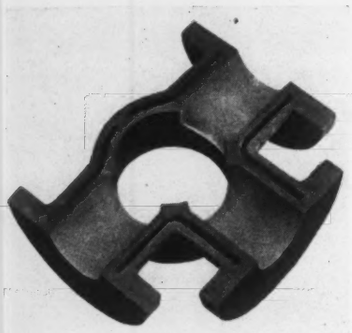
Certain types of molasses, sugar stocks, and corn syrups begin to caramelize at very definite temperatures and therefore it is not safe to heat them enough to make them flow

Modern industry uses piping for conveying many materials formerly thought unsuitable for pumping. These materials present interesting and sometimes difficult problems, many requiring heating to render them fluid enough for pumping, and a few are so charged with volatiles as to necessitate refrigeration to prevent the pump suction being killed . . . . . The authors, who have had wide experience with a variety of such special materials, discuss the factors which must be considered, concluding with practical suggestions which will help to avoid operating troubles

*Hynes Electric Heating Co., Philadelphia, Pa. Member of Board of Consulting and Contributing Editors.
†Hydraulic Engineer, Philadelphia, Pa.

freely; consequently they must be pumped while in a very viscous condition. Waxes and resins have critical melting points; that is, they change within a few degrees of temperature from a solid to a liquid. These liquids usually have no lubricating qualities whatever and introduce serious problems for avoiding undue wear on moving pump parts.

Recently some entirely new pumping problems have arisen with a material which is normally solid at ordinary temperatures but which can be considerably softened by impregnation with highly volatile liquids. This type of material must be handled at extremely low temperatures because of its tendency to disassociation.



Section through steam jacketed pipe fitting

Molasses and Similar Syrups

Let us first discuss molasses and similar syrups. Depending upon their viscosity, these materials must generally be handled in the range between 75 and 110 F, although occasionally one may be found which can be heated to 120 F without caramelizing. However, the general practice is to maintain them at from 90 to 100 F. It is necessary to install large size pipes and the lineal velocity of flow should not be more than 2 ft per sec. It is very important to operate molasses pumps at slow speed and to supply power enough to take care of the viscosity requirements. This type of material requires a steady streamline flow under a sustained squeezing pressure.

A special problem of this kind arose several years ago when cargo steamers to the Pacific found it profitable to bring back crude molasses in their empty fuel oil tanks. These tanks were generally deep in the holds and there were no suitable pumps aboard for unloading the molasses. The difficulty was overcome by keeping on the docks portable motor driven molasses pumps mounted on special bases which were suspended in the holds by cranes so that the pump suction was always close to the molasses. The pumps were gradually lowered as the molasses was pumped out, and the suction lift was thus kept within practical limits.

With many syrups used in candy, food products and so forth, the problem of discoloration is important. Excessive heat causes the syrups to change color; therefore they must often be pumped at temperatures where they are almost solid. It is impossible to wash out the lines with water and the syrup has a tendency to crystallize completely upon standing. With crude molasses, low pressure saturated steam can sometimes be introduced into a suction line to dilute the molasses and make it easier to pump. With refined syrups, however, the water would not only cause discoloration but would completely ruin them, hence steam cannot be admitted. The only solution is carefully to preheat the syrup to the maximum permissible temperature and then design pumps and piping capable of satisfactorily handling the thick material.

Waxes, Resins and Shellacs

Waxes, resins, shellac, and various allied products have very critical melting points. Piping, fittings, and pumps must be kept heated by steam or electricity to prevent their becoming plugged up solid. It is important to use pumps with heated stuffing boxes as these materials have a tendency to set in the packing when cold and in starting up the pump the packing may be torn out. In some cases, after the pump has started to handle the hot fluid, it has been found advisable to circulate water through the jacketed stuffing boxes so as to cool them somewhat, thus slightly chilling the liquid soaked in the packing. This tends to cut down leakage through the packing which might otherwise be troublesome with these non-lubricating materials. Asphalts, tars, greases, and various pitches also require heated pipes and fittings.

With motor driven pumps, it sometimes has been found advisable to install variable speed reducers and variable speed motors. This gives a far better operating result when handling heavy viscous materials such as molasses, syrups, asphalt and pitches because it is possible to run the pump very slowly when starting up so as to

Table 1—Useful Conversion Table

Multiply	By	To Obtain
Imperial gallons	10	Pounds of water
Imperial gallons	1.2	U. S. gallons
U. S. gallons	231	Cubic inches
U. S. gallons	0.134	Cubic feet
U. S. gallons	8.34	Pounds of water
Cubic feet water	62.4	Pounds of water
Cubic feet water	7.48	U. S. gallons
Barrels	42	U. S. gallons
Litre	0.2642	U. S. gallons
U. S. gallons per minute	1.43	Barrels (42 gal) per hour
Barrels per hour	0.7	U. S. gallons per minute
Barrels per day	0.0292	U. S. gallons per minute
Cubic meters per hour	4.401	U. S. gallons per minute
U. S. gallons per minute	0.2271	Cubic meters per hour
Inches mercury	0.49	Pounds per square inch
Feet of water	0.434	Pounds per square inch
Pounds per square inch	2.042	Inches mercury
Pounds per square inch	2.3	Feet of water
Pounds per square inch	0.0703	Kilograms per sq centimeter
Atmospheres	1.003	Kilograms per sq centimeter
Btu (British Thermal Unit)	778	Foot pounds
Horsepower	33000	Foot pounds per minute

Temperature degrees F = 9/5 (Temp. deg C) plus 32 degrees. Temperature degrees C = 5/9 (Temp. deg F minus 32).

"hammer" out the piping and get the material to flowing. After the lines are cleared and the material begins to flow freely, the pump speed can be stepped up gradually. Frequently the regular operating capacity of the pump can be increased 100 per cent in this way. With a single speed drive the maximum capacity of the pump is limited by the speed at which it is capable of starting; the variable speed pump drive removes starting up limitations and permits normal operation at maximum capacity.

Gas Impregnated Materials

The gas impregnated materials mentioned earlier have recently presented some unusual pumping problems. These materials are waxes and asphalt compounds which are practically solid at normal temperatures, but when they have been softened by impregnation they have a spongy appearance and a peculiar consistency which can best be described as being similar to stiff mashed potatoes. As they may contain as much as 60 per cent of absorbed volatiles, such as propane or butane, they present difficulties on the intake side of the pump. Any suction will tend to evaporate and draw off the volatiles which are needed in absorption to render the mass semi-fluid. If the gas were sucked out a solid residue would be left which would plug the line entirely. Even a small amount of free gas would seriously reduce pump efficiency.

As these materials must be handled at sub-zero temperatures owing to the low critical temperature of the volatiles the pump, piping, and fittings must be jacketed with a suitable refrigerant. An exceptionally large pump is necessary and it must run very slowly. Frictional heat generated by work in the pump introduces a problem as unless it is extracted quickly by effective cooling means it will set free enough gas to cause trouble. Very large pipe sizes are necessary to reduce resistance to flow.

The most difficult part of the problem is to get the material into the pump. In some cases a screw feed has been used. Once the material gets into a suitable pump sufficient power can be applied to squeeze it forward through the delivery piping to its destination. The high pressure and the low temperature keep the absorbed gas in its liquid form so that it somewhat softens the otherwise solid mass of the material and permits it to flow.

Horsepower and Discharge Pressures

All pumps actually deliver less capacity at the operating speed than is indicated by their theoretical displacement. The actual displacement is dependent upon several factors such as pump speed, discharge pressure, vacuum at the pump suction, viscosity and gravity of the material, operating temperature and the kind of material. The clearances between moving and stationary pump parts also are factors. Obviously, pumps designed to handle heavy molasses or asphalt require considerably more clearance than those for water or gasoline.

The horsepower required to operate any pump depends upon several factors. There is a value for theoretical horsepower and a value for actual horsepower.

$$\text{Theoretical hp} = \frac{\text{Gpm} \times \text{Weight} \times \text{Head in Ft}}{33{,}000}$$

Gpm = Theoretical gallons per minute
Weight = Pounds per gallon

The formula does not take into consideration friction losses in the pump, which vary with the type, size, speed and internal clearances of the pump, and with the discharge pressures and the viscosity of the fluid being handled. Pump friction horsepower must be obtained by actual test. By adding the friction horsepower to the theoretical horsepower arrived at by the formula, the actual horsepower input necessary for operating the pump may be obtained.

In determining the necessary discharge pressure for a given installation, it is essential correctly to compute the pressure drop due to pipe line friction. There are standard published tables which can be used for certain specified materials and conditions. In many cases, however, the only reliable data are the records of actual operating experience under similar conditions.

The conversion table and oil measurement table at 60 F will be found helpful in making pump calculations.

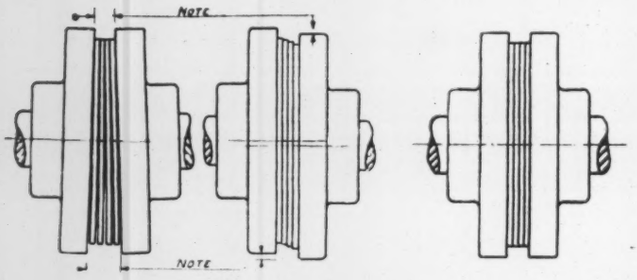
Installation of Pumps and Piping

The following practical suggestions will help to avoid operating troubles:

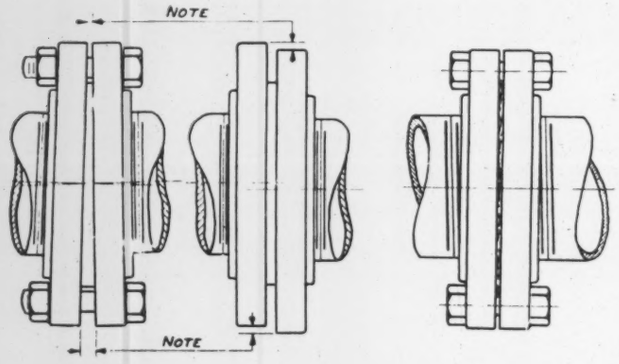
Table 2—Oil Measurement Table at 60 F

Gravity Degrees A.P.I.	Specific Gravity	Pounds per Gallon	Gravity Degrees A.P.I.	Specific Gravity	Pounds per Gallon	Gravity Degrees A.P.I.	Specific Gravity	Pounds per Gallon	Gravity Degrees A.P.I.	Specific Gravity	Pounds per Gallon
3.	1.0520	8.762	13.	0.9792	8.164	23.	0.9159	7.636	33.	0.8602	7.171
3.5	1.0482	8.730	13.5	0.9759	8.136	23.5	0.9129	7.612	33.5	0.8576	7.150
4.	1.0443	8.698	14.	0.9725	8.108	24.	0.9100	7.587	34.	0.8550	7.128
4.5	1.0405	8.666	14.5	0.9692	8.081	24.5	0.9071	7.563	34.5	0.8524	7.107
5.	1.0366	8.634	15.	0.9659	8.053	25.	0.9042	7.538	35.	0.8498	7.085
5.5	1.0329	8.603	15.5	0.9626	8.026	25.5	0.9013	7.514	35.5	0.8473	7.064
6.	1.0291	8.571	16.	0.9593	7.998	26.	0.8984	7.490	36.	0.8448	7.043
6.5	1.0254	8.540	16.5	0.9561	7.971	26.5	0.8956	7.467	36.5	0.8423	7.022
7.	1.0217	8.509	17.	0.9529	7.944	27.	0.8927	7.443	37.	0.8398	7.001
7.5	1.0180	8.479	17.5	0.9497	7.918	27.5	0.8899	7.420	37.5	0.8373	6.981
8.	1.0143	8.448	18.	0.9465	7.891	28.	0.8871	7.396	38.	0.8348	6.960
8.5	1.0107	8.418	18.5	0.9433	7.865	28.5	0.8844	7.373	38.5	0.8324	6.940
9.	1.0071	8.392	19.	0.9402	7.839	29.	0.8816	7.350	39.	0.8299	6.920
9.5	1.0036	8.365	19.5	0.9371	7.813	29.5	0.8789	7.328	39.5	0.8275	6.900
10.	1.0000	8.337	20.	0.9340	7.787	30.	0.8762	7.305	40.	0.8251	6.879
10.5	0.9965	8.308	20.5	0.9309	7.762	30.5	0.8735	7.283	40.5	0.8227	6.859
11.	0.9930	8.279	21.	0.9279	7.736	31.	0.8708	7.260	41.	0.8203	6.839
11.5	0.9895	8.250	21.5	0.9248	7.711	31.5	0.8681	7.238	41.5	0.8179	6.819
12.	0.9861	8.221	22.	0.9218	7.686	32.	0.8654	7.215	42.	0.8156	6.799
12.5	0.9826	8.193	22.5	0.9188	7.661	32.5	0.8628	7.193			

Locating and Mounting—It is always advisable to place the pump as closely as possible to the source of fluid supply. It should be mounted on a solid foundation with anchor bolts set in pipe nipples to allow for adjustment. The base should be perfectly level, using steel wedges between it and the foundation. Care must be taken in tightening up the anchor bolts to avoid springing the base; if the base is sprung, the pump will be thrown out of line with its outboard bearings if belt or gear driven, or with the couplings if direct connected. After leveling the base and tightening the anchor bolts, the cap screws holding the outboard bearings to the base should be loosened and a check made to see that the outboard bearings slide freely on the base but without any rocking, and that the cap screws do not bind sideways in the holes. Unless everything is free, it is necessary to loosen the anchor bolts and reline the pump base on the foundation.



The wrong (left) and right ways to connect flexible couplings



The wrong (left) and right ways to connect pipe flanges

Lining Up—If the pump is direct connected, care should be taken to see that the couplings line up properly. They should be lined up so that their faces are parallel and they should measure the same distance apart at all points. The sketches show the right and the wrong ways to line up flexible couplings and pipe flanges. After properly lining up, the pump base can be grouted in.

Piping Riser Essential—When making piping connections, the pump discharge pipe should not be carried out and then directly down. It is essential that a riser be installed on the discharge side of the pump, even though it is necessary to drop down again to a line at lower level. The riser should be placed directly at the pump discharge. This practice has been found necessary for sealing pumps in high vacuum service or where there is any vapor in the material. The right and wrong way to connect pump discharge pipes is illustrated.

It is good practice to put a valve at the top of the riser to be used as a vent when starting up the pump.

Piping Precautions—All piping to and from the pump must be of ample size to carry the maximum quantity of liquid to be handled without undue friction. Short turn elbows should be avoided and long turn or 45 deg elbows and long sweep pipe bends should be used wherever possible. When drawing or forcing liquids long distances or when handling very thick viscous materials, the diameters of pipe lines should be greater than called for by the openings on pumps. They must be large enough to convey the material with a minimum amount of friction. This is particularly essential for the suction pipe, which is positively limited to atmospheric pressure (only 14.7 lb per sq in. maximum) to force the material from its source to the pump.

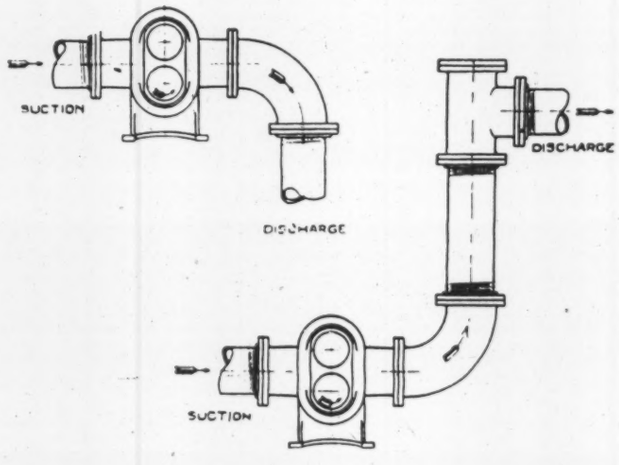
Suction Must Be Air-tight—The suction of a pump should be perfectly air-tight. Any leak will destroy the vacuum and prevent the material from rising to the pump.

A suitable air-tight but easily cleaned strainer of ample size must be installed in the suction line to prevent passage of any foreign substance which might damage the pump. Be sure that suction and discharge pipes are free of dirt and foreign material before coupling up to the pump.

Hot water or volatile liquids cannot be lifted by suction to any considerable height and the difficulty increases with rise in temperature. To handle volatile liquids efficiently they must flow by gravity to the pump intake.

Cold Weather Precautions—Materials which flow freely in warm weather may cause trouble during cold weather unless they are heated. In exposed locations pumps and piping should be thoroughly drained after starting if the material is likely to freeze.

All steam pipes should be installed so that they can be easily drained of condensation. For some locations steam jackets for pumps and piping are difficult to drain and frequently it is safer and more satisfactory to use electric heat instead of steam. This can readily be applied to pipe lines, valves, pumps, and so forth.



Wrong way (left) to connect the discharge pipe (without a riser), and right way to connect the discharge pipe (with a riser)

Modernizing with Air Conditioning

By **Anker Winther***

THAT modernization by air conditioning is not limited to old, out-of-date buildings is well demonstrated by the action of the American Druggists' Fire Insurance Co. in equipping its 15 story American Building, Cincinnati, with a system embodying many features and refinements, including a new type of duct construction.

Fourteen floors of the building are devoted to public office space, the fifteenth serving as a home office for the owners. Even before it was air conditioned this building, only six years old, was considered one of Cincinnati's most modern and best equipped.

Why the Building Was Air Conditioned

Underlying reason for the investment was, of course, economic. Cincinnati, in common with other cities, has had for the past several years a surplus of high grade office space, the result being that most of the better buildings are but partly occupied, and the market for space is extremely competitive.

There were two courses open to the management to increase the percentage of occupancy. One was obvious —to make a general reduction in rental rates. The other was to better the service offered to the tenants, making the building so attractive and establishing its superiority sufficiently that it would be removed from price competition. This was chosen as being the more constructive, as it was felt that rental reductions would upset the market for office space and would detract from the prestige of the building—perhaps with permanent effects.

After thorough study, it became apparent to the owners that there were a number of reasons air conditioning would be advisable. Its value as an inducement to prospective tenants was, of course, most important. In many cases the promise of increased personal comfort alone would be sufficient to rent space. To organizations having a large number of employes, the sale of office space would be placed on a definite economic basis by citing the effect of air conditioning in increasing the summer productiveness of office workers and in decreasing absences due to illness both summer and winter. Doctors and dentists would be attracted by the increased comfort they could offer their patients.

Aside from its direct appeal to the tenants, air conditioning was found to have tangible value in the operation of the building. By keeping turn-over of tenants at a minimum, expensive moving and altering of partitions is reduced. With windows closed, dust and dirt are kept out with consequent reduction in cleaning, painting and redecorating costs.

Choosing the Type of System

Choice of the proper type of system was a matter of considerable study by the management and Carl J. Kiefer, Cincinnati, the consultant. The principal factors influencing the selection of the equipment were: (1) results obtainable; (2) effect of the installation on the appearance of the building; (3) amount of rentable space lost through the installation of the equipment; (4) adaptability to changes in office divisions; and (5) cost. Three methods were considered, the first being the use of individual surface cooling units served from a central water cooling plant. This was rejected because of the difficulty which it was felt would be incurred in providing proper ventilation without unsightly outside air intakes, marring appearance of ceilings by installation of chilled water piping and drains, space requirements in the offices, and the difficulty of properly serving small subdivided offices without an excessive number of units. Consideration was also given to surface cooling unit air conditioners centrally located on each floor with ducts supplying the various offices, the chilled water to be circulated through the coils from a central water cooling plant. This was not considered practical because of space requirements.

A central station dehumidifier system was decided upon as best meeting the requirements of this building. Although a plant of this type was not the lowest in cost, the desirability of having washed air and rigid control of both temperature and humidity the year 'round was considered to warrant the additional expense. It was readily

Selection of the type of system which can best be adapted to the particular requirements is perhaps the principal consideration in modernizing by air conditioning. Earlier articles have described applications of the indirect system, chilled water being circulated from the refrigerating equipment in the basement to conditioning units at various locations, and a system of direct expansion units on each floor with compressors in the basement..... This month, a central station job comprising two centrally situated dehumidifiers supplied with chilled water from a basement refrigerating plant is described. Features of the installation are the method of duct construction employed, which avoided the expense of furring yet made an installation neat in appearance, and the duct layout, which allows for any normal subdivision of office space

*Cincinnati Branch, York Ice Machinery Corp.

apparent, however, that there would be some difficulty in adapting a central station layout to this well built steel and concrete structure with its finely finished interior without marring its appearance or encroaching upon rentable space.

Location of Compressors and Dehumidifiers

The lower twelve of the floors devoted to office space have overall dimensions of 100 x 60 ft, the upper three floors forming a tower roughly 60 ft square; total rentable floor area is approximately 65,000 sq ft. An adjoining four story building on the north is also the property of the owners of the American Building.

The refrigerating and water cooling equipment furnishing chilled water to the dehumidifiers is in the basement of this adjoining building in a space 9 x 66 ft. "Freon" is the refrigerant with a shell-and-tube water cooler in which the refrigerant is sprayed over the tubes by a recirculating pump. Two hundred tons of refrigeration is provided by two 2-cylinder compressors, one 14 x 10 in. direct connected to a 150 hp synchronous motor, and the other V-belt driven by a 60 hp induction motor. Each compressor is equipped with capacity reducing partial cylinder bypasses, making the operation of the system flexible over a range of from 15 to 100 per cent of full capacity, with no reduction in efficiency.

Condensing water is taken from the city mains at a midsummer temperature of 85 F, the quantity used being regulated to hold a fixed condensing pressure by means of a diaphragm valve. The main chilled water circulating pump, supplying 700 gpm of water to the dehumidifiers on the upper floors of the building, is also in the machinery room.

In order to hold the main riser ducts within necessary space limits, the dehumidifying and air distributing equipment is divided into two systems, one serving the lower five and the other the upper ten floors. The dehumidifier for the lower system is on the fourth floor of the adjoining building and for the upper system, a space on the tenth floor 16 x 20 ft was set aside as an equipment room. Chilled water from the main circulating system is supplied to the dehumidifiers at the inlets to the spray pumps through 3-way mixing valves, dew point regulation being used in the dehumidifiers.

The tank of the lower dehumidifier is partitioned to form a sump into which its return water overflows, and which also collects the return water overflowing from the upper system. Thus, there is a balanced head on the circulating system as far as the fourth floor level.

For air distribution and control, each half-floor has its own individual recirculating fan, the building being zoned east and west. Two main supply ducts convey air directly from the dehumidifiers to the inlets of the recirculating fans, where the air is combined with the proper proportion of bypassed air as governed by the thermostatically controlled mixing dampers.

One of the most important problems was finding suitable space for the duct risers. None was available in the compactly arranged offices and corridors and the building is so located that ducts could not be placed on the outside. The only unused space that could be found in the building, other than two shafts rather limited in size, was in the stairways, which are constructed with four landings leaving a well in the center.

Accordingly, the central systems were laid out so that the main supply ducts could be accommodated in the stairwells, and the return air in the two shafts. As the recirculating fans are hung directly from the main stair landings, this arrangement requires only a very short connection to the main supply duct. On the first four floors of the building the riser and circulating fans are on the inside wall of the adjoining building.

New Type of Duct Construction Used

The feature of the installation is the construction and arrangement of the distributing ducts on the various floors. It was the management's desire to avoid the expense of furring in the supply ducts, yet it was of equal importance that the installation be neat in appearance.

OPPOSITE

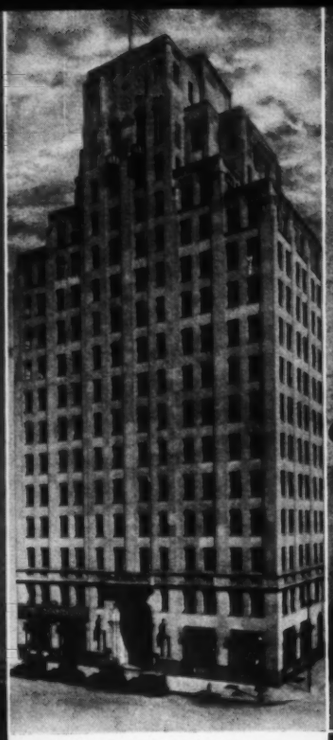
***Left, top to bottom*—Original appearance of a north wall and ceiling before ducts were installed. . . . Bare ducts in place alongside ceiling beam and over windows. . . . Same view showing neat appearance after duct work was finished off and painted. . . . *Center, top to bottom*—The American Building, Cincinnati, air conditioned last year. . . . Detail of method of duct construction. . . . 5 hp slip ring motor driving exhaust fan. . . . *Right, top to bottom*—150 hp synchronous motor for the large compressor. . . . 60 hp induction motor for smaller compressor. . . . ¾ hp motor for booster unit, one of two for each floor**

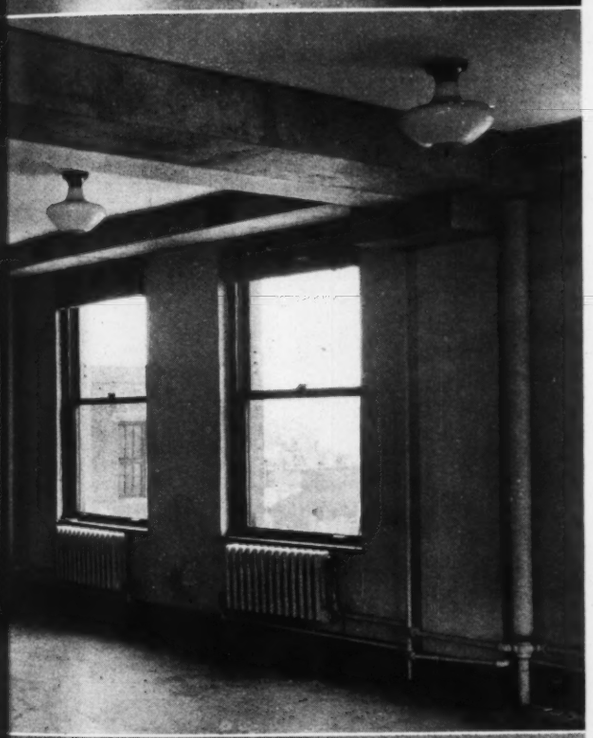
These requirements resulted in the development of a type of duct construction which is smooth and continuous at the seams, and in which no hangers are visible.

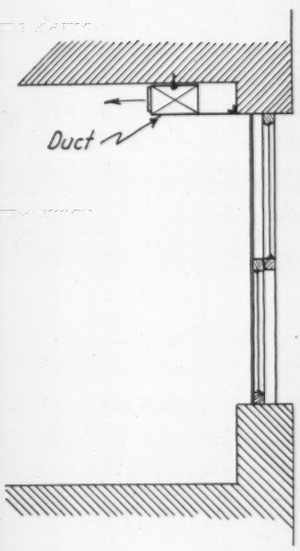
Object of the design was to simulate as closely as possible the dropped beam construction of the ceilings, and for this reason, all elbows were made square. To reduce frictional pressure drop, each elbow was fitted with a deflector consisting of a number of closely spaced turning vanes. The deflectors were purchased in the form of large slabs, which were cut up into pieces of the proper size on the job.

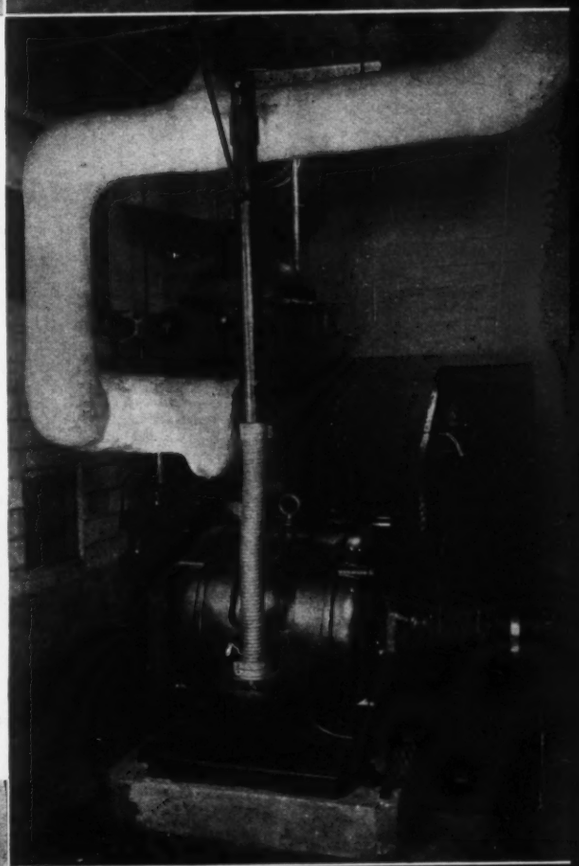
Where the ducts run along a wall, the front face is maintained continuously for the length of the run, and the width is reduced in accordance with proper design from the rear. To carry out the full beam effect, the bottom sheet is carried back to the wall, closing up the space between the duct proper and the wall. (See sketch.) Three of the photos show the north wall of a typical floor, before, during, and after the installation of the ducts. Note that although the ducts received no finish other than filling in the cracks and two coats of paint they cannot be distinguished from the beams without close inspection.

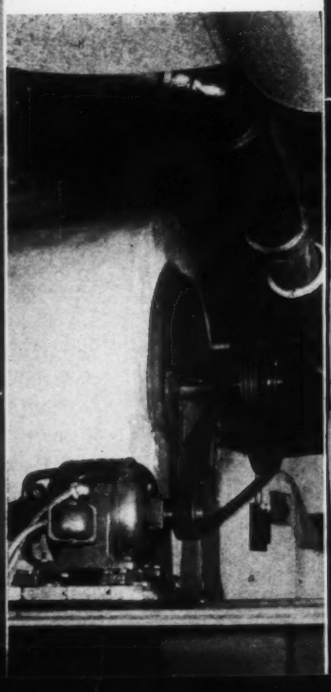
Duct location on a typical floor is shown in the plan reproduced here. The layout is designed to make the air supply system universal for any normal subdivision of the office space, a feature of considerable importance in view of the changes that are frequently required in office divisions by change in tenancy as otherwise such changes would necessitate expensive and unsightly alterations in duct branches and air outlets. Every grille is either above or near a window, the general direction of air discharge being towards the center of the building. In this manner, practically any office is assured a supply grille with the ducts as originally installed, for very rarely will individual offices be so arranged that they do not have a window. Divisions of the offices toward the center of the building, usually reception rooms, are

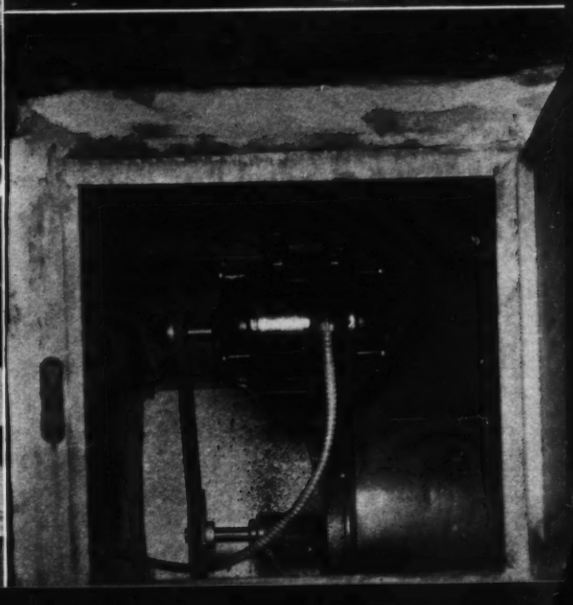


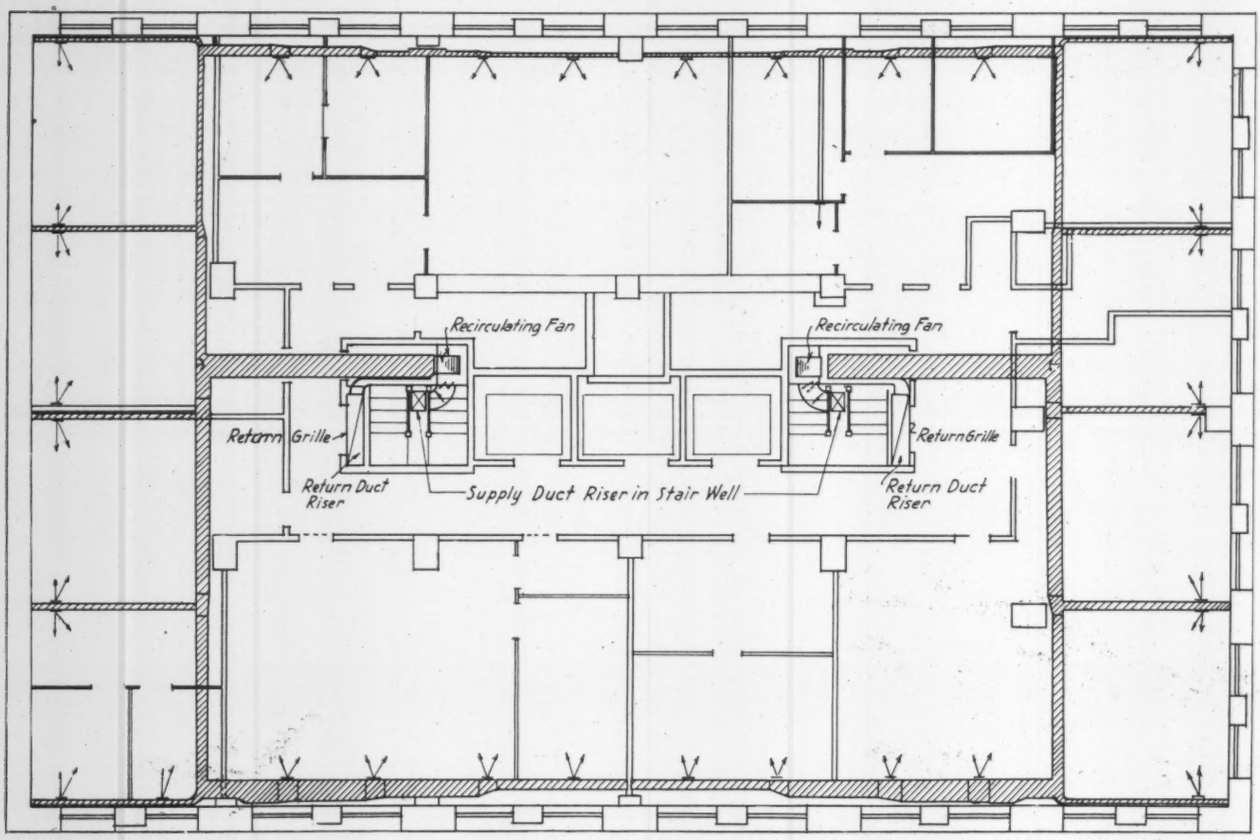



Duct









Duct location on a typical floor. The layout is designed to make any normal subdivision of office space possible without affecting the air distribution

served by the air returning to the corridor with which is mixed an appreciable amount of conditioned air which travels directly from the grilles through the transoms into these spaces.

All air outlets have high velocity directional flow registers fastened directly to the face of the duct. The key operated dampers provide for adjusting the supply system, and also permit manual regulation of temperatures in individual offices.

Control Is Almost 100 Per Cent Automatic

The control system provides almost 100 per cent automatic regulation, rather unusual in an installation of this size. Complete automatic control is very desirable in this instance since the building is operated with a minimum of mechanical equipment, requiring the services of only one engineer. Since the operation of the air conditioning plant requires only periodic visits to the engine room, the engineer has found no difficulty in adding this duty to his other work.

Summer temperature control centers about the zone thermostats, there being an instrument in the east and west return air intakes on each floor. These are pneumatically operated, and by means of an outdoor master thermostat their setting is automatically compensated for changes in outside temperature. The zone thermostats are set for an inside temperature of 80 F when the outside temperature is at the maximum design condition of 95 F, and the ratio of readjustment provides for a drop in the inside temperature to 72 F as the outside temperature falls to 70 F. The zone thermostats control the operation of the dehumidified and bypass air mixing dampers at the recirculating fans.

Since the humidity is determined by the dew point temperature of the air leaving the dehumidifier, the requirement of 50 per cent relative humidity in the rooms necessitates a change in the dehumidifier temperature to correspond to changes in the room temperature. To accomplish this, the dew point regulator is of the submaster type, readjusted by the outside master to provide a lower dew point temperature for lower inside temperatures and *vice versa*. The dew point regulator functions through a 3-way mixing valve, which admits the required amount of chilled water from the circulating system to maintain the desired temperature.

If the quantity of chilled water required for the dehumidifiers falls, there will be a corresponding lowering of its temperature, with the result that a thermostat having its bulb in the water leaving the cooler, will stop the smaller of the two compressors. A rise in the chilled water temperature over the desired point will re-start the compressor. The large compressor is started manually in the morning, its capacity being set as closely as possible to the anticipated load by means of the cylinder bypasses. The starting and stopping of the automatic compressor evens out any differences between the actual and the anticipated loads. During the day's operation, if the engineer notes that the automatic compressor is operating continuously, a readjustment is made in the capacity of the large compressor.

The amount of condenser water is regulated in accord-

ance with the air conditioning load by a throttling valve actuated by pressure from the condenser.

Winter control is arranged to heat to 72 F all outside air used for ventilation, and to humidify the air to the proper point. The present system of radiation still functions as in the past. A thermostat in the main supply duct, controlling the steam valve on the reheater, provides the temperature control. Humidity is regulated by a hygrostat in the main return duct for each system, the setting of which is readjusted automatically by an outside master thermostat so that in cold weather the inside humidity is kept below the point at which the windows begin to fog. The hygrostat regulates the admission of steam to the preheater coils, and also controls the flow of water to a section of spray nozzles.

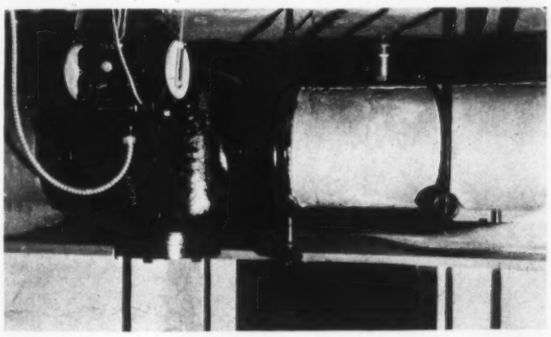
No detailed analysis of operating costs for the 1935 season has as yet been made. Careful observations were made however, of the temperature distribution on the various floors, as the principle of supplying air from the outside walls had been questioned. Tests showed remarkable uniformity in readings taken near the windows under the outlets, and at random points in the offices.

Along the outside wall there is a very perceptible upward induction of air from the floor into the air stream leaving each outlet. Had it been intended, however, to heat the building completely by means of the air distributing system, without the direct radiation now installed below the windows, some other system of air distribution would probably have been used.

The management of the building has received much favorable comment from tenants in addition to a great deal of public attention on the addition of air conditioning to the services offered. Air conditioning was directly responsible for the rental of considerable space during the 1935 season, and there is no doubt that it will be even more helpful this year.

TROUBLE-SHOOTING—

Bringing Back the Missing Water Line



A vacuum breaker brought back the missing water line

By **H. G. Schaefer**

IN a heating system for a parochial school and a church the piping system is arranged in three zones, one of which supplies the auditorium, the second supplying the school-rooms, and the third the church; each of the three is separately valved in the boiler room, both supply and return. A convenient set-up for the application for zone thermostatic control, you will agree. And so, motor operated valves and controlling thermostats were installed.

But when the fires were started in the fall, the fun began. The fireman fought manfully against the growing conviction that a playful banshee was toying with his water line. He broke down, however, after losing his water line four times on the first day, and sent out a call for help.

What had occurred was this:—As soon as the heat demand was satisfied in a particular zone, that thermostat caused its valve to close. The steam within the zone system continued to condense, and presently enough vacuum was built up to overcome the pull of the pump, and to induce the condensate in the flooded return header to back up into the shut-down system.

Naturally, the thing to do was to cut check valves into the three group return mains, and this was promptly done. But did the water stay put? Not by a jug-full! Why? Well, for one thing, because good mechanics had made the original installation. The system was completely air-tight, and built up and held a vacuum as high as 22 in. The vacuum pump operated between the limits of 4 and 8 in.

When a governing thermostat demanded steam, the valve gradually opened, grudgingly admitting enough steam to fulfil the demand, but not enough to break the vacuum to within the pump range. Naturally, all the condensate stayed within the system until piping and radiators were flooded, to the continued distress of the fireman, and the jeopardy of the boiler.

Eventually the problem was solved. The illustration shows a bit of equipment screwed into the top of the main, just abaft the control valve. Yep! You've guessed it. It's a vacuum breaker, and is set to operate at 3½ in., so that the pump has a little leeway at all times.

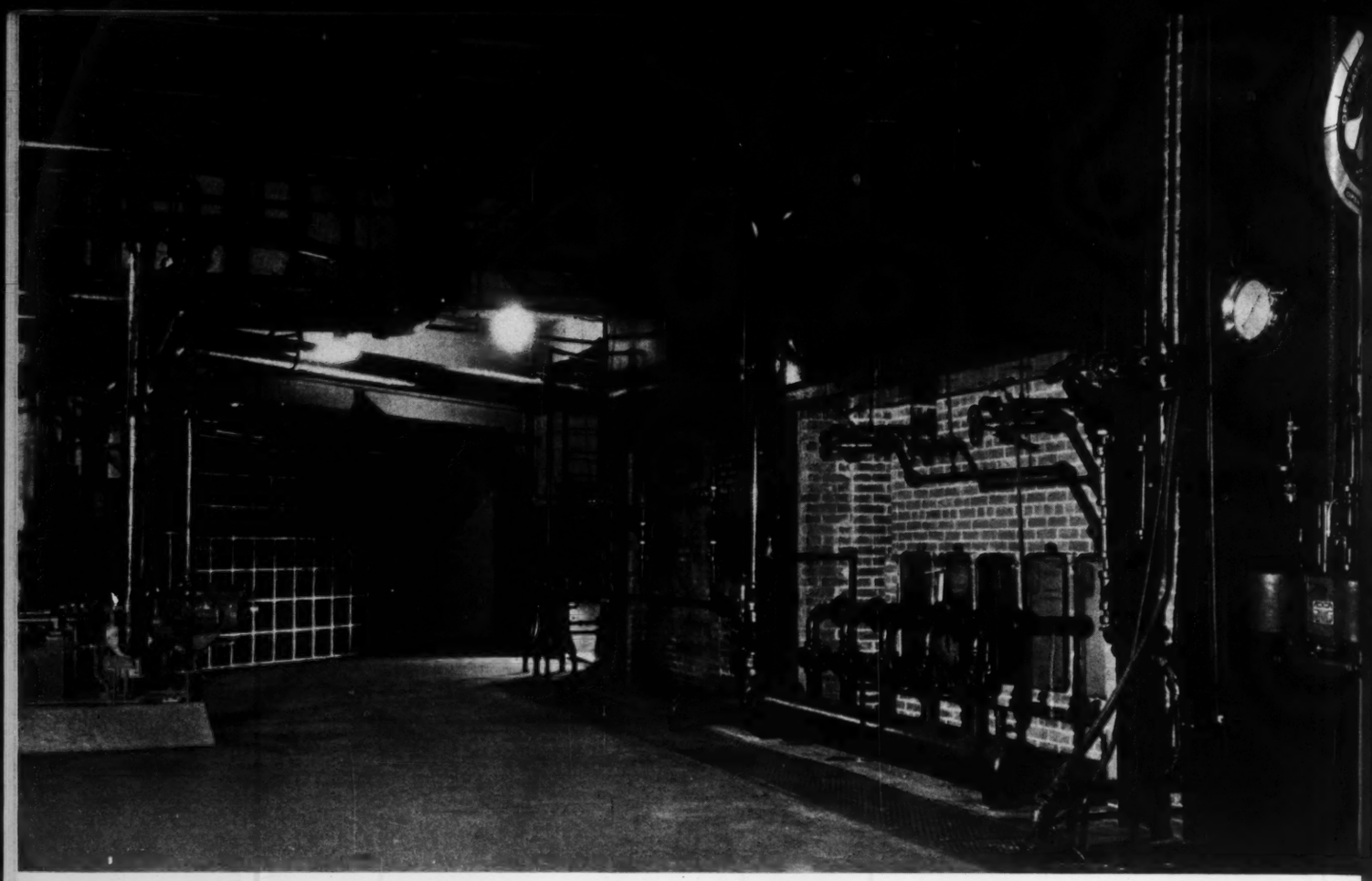


Fig. 1—The gas and oil fired boiler at the Palmer House, Chicago, showing the gas header along the floor with the leads to the five burners. At the extreme left are the gas boosters, and at the extreme right the uptake damper control; the large dial shows the positions of the gas butterfly valve and the uptake damper

Gas in Summer, Oil and Coal in Winter, Carry Palmer House Hotel Heating Load

AN interesting feature of the mechanical equipment of the Palmer House, headquarters for the annual meeting of the *American Society of Heating and Ventilating Engineers* to be held in Chicago later this month, is the combination gas and oil fired boiler placed in service last spring. The change-over from coal firing was based strictly upon economic considerations after a new rate for large users of gas during the summer months known as "Classification 5" went into effect. This rate is aimed to create a market for the gas the utility must take from the pipe line in summer, which amount depends on the demand in winter and includes that required for house heating. Rates under this classification are, for the first 130 therms used per month, 6c per therm; the next 130 therms, 5c; the next 9740 therms, 3c; the next 65,000 therms, 2c; and over 75,000 therms, 1.8c per therm. (A therm is equivalent to 100,000 Btu, and as the gas has a heating value of 800 Btu per cu ft, 125 cu ft are equal to 1 therm.) The charge jumps to 35c per therm after November 1 to drive loads under this classification off the lines.

The scheme used at the Palmer House is therefore to burn gas until November 1, and after this date to fire with oil and coal. The 645 hp gas and oil fired boiler, generating steam at 130 lb, is large enough to care for the summer load with the stoker fired boilers as standby; in winter as many stoker fired boilers as necessary are operated as near as possible to the most efficient rating, and the oil fired boiler (which is under automatic control) operates to care for fluctuations in steam requirements. Applications of this method comprise buildings having large steam requirements in summer, such as office buildings generating their own power, hotels with large process and water heating loads, etc.

Fig. 1 is a view of the gas and oil fired boiler, showing the 10 in. gas header along the floor by the boiler with the five 3 in. leads to the burners, each of which has a capacity of 15,600 cu ft of gas per hr at a pressure of about 15 oz. Fig. 1*A* is a close-up of the gas header which also shows the oil piping, installed after the photo for Fig. 1 was made.

At the extreme left of Fig. 1 are the gas boosters, a close-up of which is shown as Fig. 2. Each of the two boosters has a capacity of about 80,000 cu ft of gas per hr at 14 oz static pressure and is driven by a 10 hp steam turbine. At the right of Fig. 2 is the gas meter, with the 12 in. main from the street coming in at the top and from which the gas goes to the boosters.

An interesting feature of the mechanical equipment of the Palmer House hotel, Chicago, is the combination gas and oil fired boiler put in operation last spring, gas at low rate being available from April to November, after which oil is used. The changeover was made purely because of economic considerations . . . . . Many readers will be stopping at the Palmer House during the A.S.H.V.E. meeting and the International Heating, Ventilating and Air Conditioning Exposition this month, and will have an opportunity to see this installation

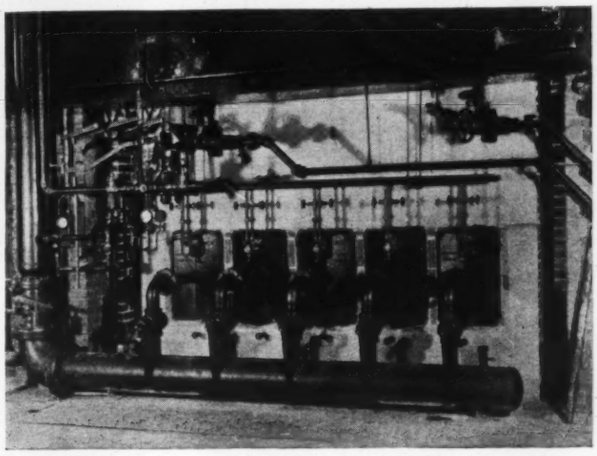


Fig. 1*A*—Close-up of the gas header seen in Fig. 1, and the oil piping and connections to the oil burners. The butterfly valve controlling the gas pressure is seen in the header at the left

Fig. 2 (left)—Close-up of the turbine driven gas boosters, left, and the gas meter on the posts at the right . . . Fig. 3 (center) Bricked in front of the gas and oil fired boiler after removal of the stoker . . . Fig. 4 (right)—Interior of furnace looking toward the gas burners: there are two spuds for gas in each hole and air is drawn through these holes. For oil firing, the oil guns are inserted in the center hole in the second row from the top in each of the five sections

The line from the boosters to the 10 in. header at the boiler is 8 in. All of the gas piping was arc welded, and the oil piping was oxy-acetylene welded.

Fig. 3 shows the bricked in front of the boiler illustrated in Fig. 1 after removal of the stoker, and Fig. 4 is an interior view of the boiler furnace looking toward the gas burner end.

The Method of Control

The method of control for gas and oil firing is a feature of this job—perhaps the outstanding one. For gas firing, a butterfly valve in the gas main to the burners (seen at the extreme left of Fig. 1*A*) is controlled by the pressure in the steam header, and in turn controls the gas pressure to the burners. The gas pressure in the header controls the air operated uptake damper by means of a leak-off valve to maintain proper CO_2 content of the flue gases. The positions of the damper and the butterfly valve are shown by the two hands on the large dial at the right of Fig. 1, the darker hand for the butterfly valve and the other for the uptake damper. For oil firing, the pressure in the steam header controls the oil and steam throttling valves to the burners and the oil pressure in the manifold controls the uptake damper.

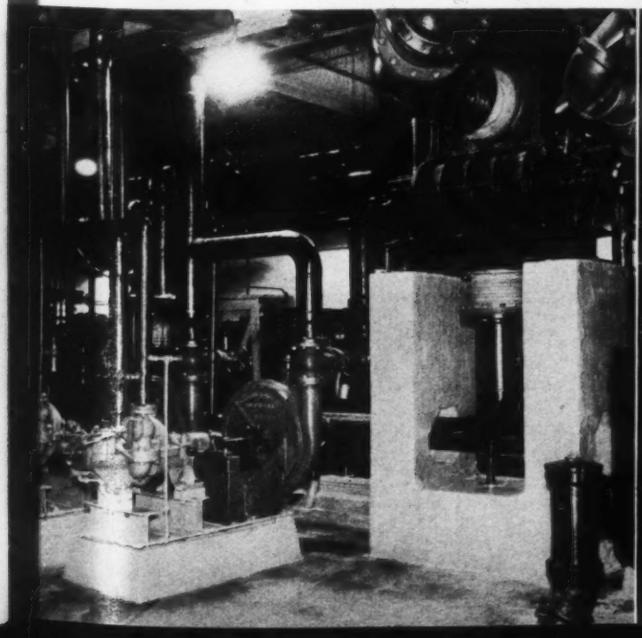
The gas and oil piping systems are of course entirely separate, as are the burners, although they are installed in close proximity. As can be seen from Fig. 1*A*, the leads from the gas header come up from the header along the floor to each gas burner. The oil and steam lines are above the gas header, and the leads to each of the steam atomizing oil burners drop from this line. By means of a bracket connection, the oil guns may be taken out of the boiler during gas operation.

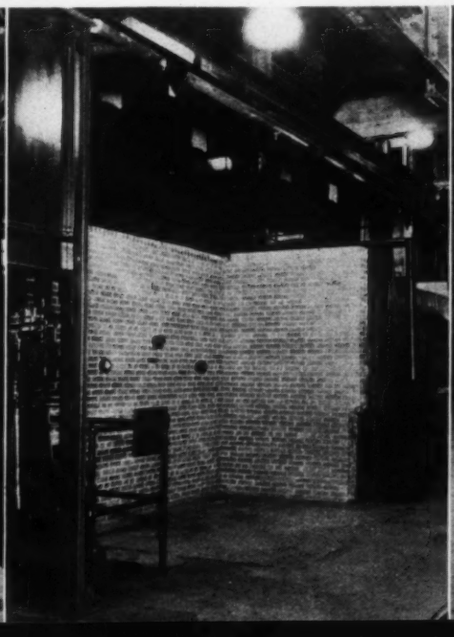
The pilot line for lighting the gas burners is taken off the gas header directly ahead of the butterfly valve.

Gas Consumption and Efficiency

Results after five months' operation to November 1 have fully met expectations. During this period (June 1 to November 1) 827,666 therms or 103,458,250 cu ft of gas were used and 58,663,540 lb of steam were generated. The load ranged from 50 to 200 per cent of boiler rating, and the average boiler, burner, and furnace efficiency for the period was 72 per cent. Incidentally,

[*Continued on page* 21]





Air Conditioning a Production Tool Since 1926 at Bayuk Cigars Plant

By **Rush D. Touton***

SINCE progress of the future is built upon the experience of the past, it is often useful to review the experience of a pioneer in an activity. Bayuk Cigars, Inc., has been employing air conditioning for 9 years; the case is particularly interesting because increasing production schedules and continued adaptation of new methods have charted a further course of progressive development.

The Bayuk factory and office building at 9th and Columbia Avenue, Philadelphia, was erected in 1926 and represented what was then considered an unusual cigar making plant, as a production of 200,000,000 cigars per year in one plant was thought impossible and impracticable; furthermore, it was decidedly novel to include all phases of tobacco treatment and process work in the same building with the actual rolling of the cigar.

The design included all the processing practices developed and standardized by the firm in its 30 years' cigar making experience. Air conditioning and refrigeration was provided for the comfort of the operatives and to permit year 'round uniformity of cigar manufacturing, and the structure was completely insulated, provided with double windows and fixed sash to create a giant "humidor." The building afforded 200,000 sq ft of floor space on eight manufacturing levels, all conditioned by the following equipment:—

Two central station systems, each handling 40,000 cfm, one in the basement serving the lower four floors, and one in a ninth floor pent house serving the fifth, sixth, seventh and eighth floors.

Four compartment type drying systems for filler tobacco.

Five fermentation rooms on the first floor.

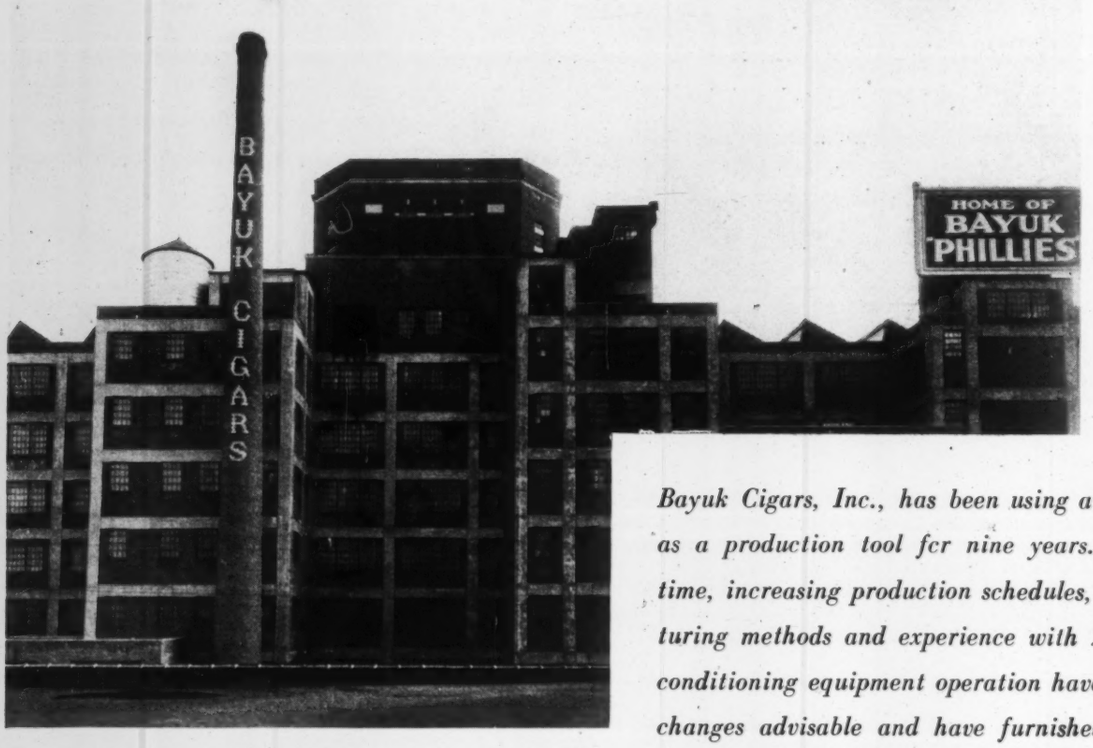
A finished cigar conditioner on the eighth floor.

A separate ventilating system for the seventh floor general and executive offices.

Two low temperature storage rooms for processed tobacco, equipped for maintaining 85 to 90 per cent relative humidity at temperatures of 65 to 70 F.

A total of 200,000 cfm was circulated by the original air conditioning equipment with an installed motor capacity for this service, including refrigeration, of 400 hp. Steam was supplied from three low pressure oil fired boilers, circulating at 3 lb pressure through an open return gravity type piping system. Purchased

*Technical Director, Bayuk Cigars, Inc., Philadelphia, Pa.



The Bayuk plant and office building at 9th and Columbia Avenue, Philadelphia, showing the fourth to eighth manufacturing floors and the ninth and tenth floor penthouse construction enclosing the condenser water spray pond, central station humidifier and dust arresters. The fresh air intake for this humidifier and the refrigeration storage tank are also shown

Bayuk Cigars, Inc., has been using air conditioning as a production tool for nine years. During that time, increasing production schedules, new manufacturing methods and experience with 24 hour a day conditioning equipment operation have made certain changes advisable and have furnished a wealth of information about industrial process air conditioning..... The author summarizes Bayuk's experience in this very practical article

power was arranged for, with a transformer installation receiving energy at 2400 volts and distributing at 220 and 110 volts. Because of the large number of small induction motors, a low power factor was anticipated and to correct this, 150 kva of correction was installed. A 100 ton centrifugal refrigeration compressor was installed in the basement with an enclosed spray pond on the tenth floor of the building for cooling the condensing water.

In grouping all the cigar making and the tobacco processing work, a wide variety of air conditioning load concentrations appear. For instance, of the 3,000 people employed initially, 900 were on the fifth and sixth floors. Also on these levels was a suction system removing approximately 30,000 cfm as required by the cigar making machines. In addition, a high heat load existed here due to the 100 hp of installed motor capacity on the cigar making units and conveyors. In contrast, the fourth floor, used for the final mellowing of the tobacco before developing the actual cigar, had a maximum of 30 employes and 10 hp. This operation consists of a two months' natural storage treatment of the leaf, and consequently a negligible heat load is developed.

Similar load diversification existed in many areas, and it required considerable ingenuity to combine the loads and apportion the conditioning air so that a minimum of conditioning units would suffice. Investigation of the relative merits of central station and unit type equipment dictated a decision in favor of the divided system.

With this original equipment as a nucleus, we have now had nine years' operating experience, during which time there has been a constant 24 hour daily demand on the equipment. Probably no better proof of the essential soundness of the original planning is needed than to consider the doubling of sales of Bayuk "Phillies" cigars, all of which are made in this building.

Increased Production, Developments, Have Required Changes

Some changes have necessarily been advisable. Increased production naturally has increased the load on the air conditioning system, particularly in the many continuous processing services. These utilize 60 per cent of the floor space and production increases are reflected in direct proportion in space requirements. Development work has resulted in installation of a number of new processes of which closely controlled air conditioning is an essential feature, and additions have been built to provide required space for locker rooms and other incidental services. However, the general air conditioning system has been adapted to serve the new requirements with only minor changes, of which the following are examples:

Spray Banks—It was found that the central station units, originally equipped with one bank of sprays delivering in the direction of the air flow and another opposed, would deliver saturated air when the outside wet bulb depression did not exceed 12 F. Under greater outside depressions, difficulty was encountered in holding the required 70 per cent relative humidity in the manufacturing areas because the air emerging from the final distributing ducts would range between 3 and 4 F depression; this trouble was accentuated when an attempt was made to use refrigeration on dry days. The obvious effect was that the reduction in the wet bulb temperature was not accompanied by sufficient reduction in the dry bulb temperatures on the floors. The result was that the relative humidity was lowered below the desirable point when the full tonnage was applied to the central station unit.

This difficulty was corrected by arranging both banks to spray in the direction opposed to the air flow. With this method, the wet bulb depression of the air leaving the ducts is less than 2 F even under maximum outside conditions of 15 to 18 F wet bulb depression (this includes the reheating effect of the fan). The improvement in saturating efficiency agrees closely with the data on this subject given on p. 184 of the 1935 *A. S. H. V. E. Guide*.

Nozzles—In these same units, the original nozzle openings were $\frac{3}{32}$ in. These orifices have been changed to $\frac{1}{8}$ in. to decrease the required differential between the cooling water and the leaving dew point of the air by raising water to air volume ratio; a further operating advantage was obtained since the $\frac{1}{8}$ in. opening does not clog as readily as a smaller size, and all recent installations have used $\frac{1}{8}$ in. orifices or larger.

Control—Originally equipped with dew point control on the central station systems, an alteration was made so that the dew point is now controlled by hygrostats on representative floors, working within a high and low limit arrangement with a master thermostat at the humidifier discharge. The system is now much more responsive to rapid load variations, as caused, for example, by stoppage of the suction system for lunch periods, etc. The limit device prevents too great a variation in either direction and is particularly useful in maintaining minimum temperatures over week ends, etc.

Off Peak System—The refrigeration for comfort cooling and dehumidification as originally installed was of 100 ton capacity, arranged to serve only the upper four floors of the building, where the greatest motor load and operator concentration existed. After one year's experience, a heat exchanger was put in to permit securing refrigeration from the same compressor and cooled water circulating system for the lower four floors. With the storage and offpeak system in use, this part of the air conditioning system is operated approximately 1200 hours per year. From this total of compressor operation, 500 hours of direct refrigerating effect are employed for the manufacturing areas and approximately 1500 hours are secured indirectly from the storage system for conditioning the lower dew point areas.[1]

An interesting consideration arises here as to the optimum refrigeration capacity or design factor which should be used for this type of work. There is, of course, no difficulty in maintaining comfortable conditions on dry days even though the outside wet bulb may be quite high. The maximum demand occurs when the outside depression is small, for instance 3 or 4 F, creating a high demand for latent heat removal to obtain a desirable relative humidity. Our conclusion is that refrigeration is invaluable to precise cigar making, and that it is good economics to design for a maximum of 75 F outside wet bulb in climates similar to that of Philadelphia. Planned and installed on this basis, the refrigeration will pay for itself in two years in direct saving, without considering

[1] "Increased Air Conditioning Capacity with Economy," by R. D. Touton, Heating, Piping and Air Conditioning, July, 1934, pp. 285-288.

the somewhat intangible, though real, importance of increased quality and uniformity of the product.

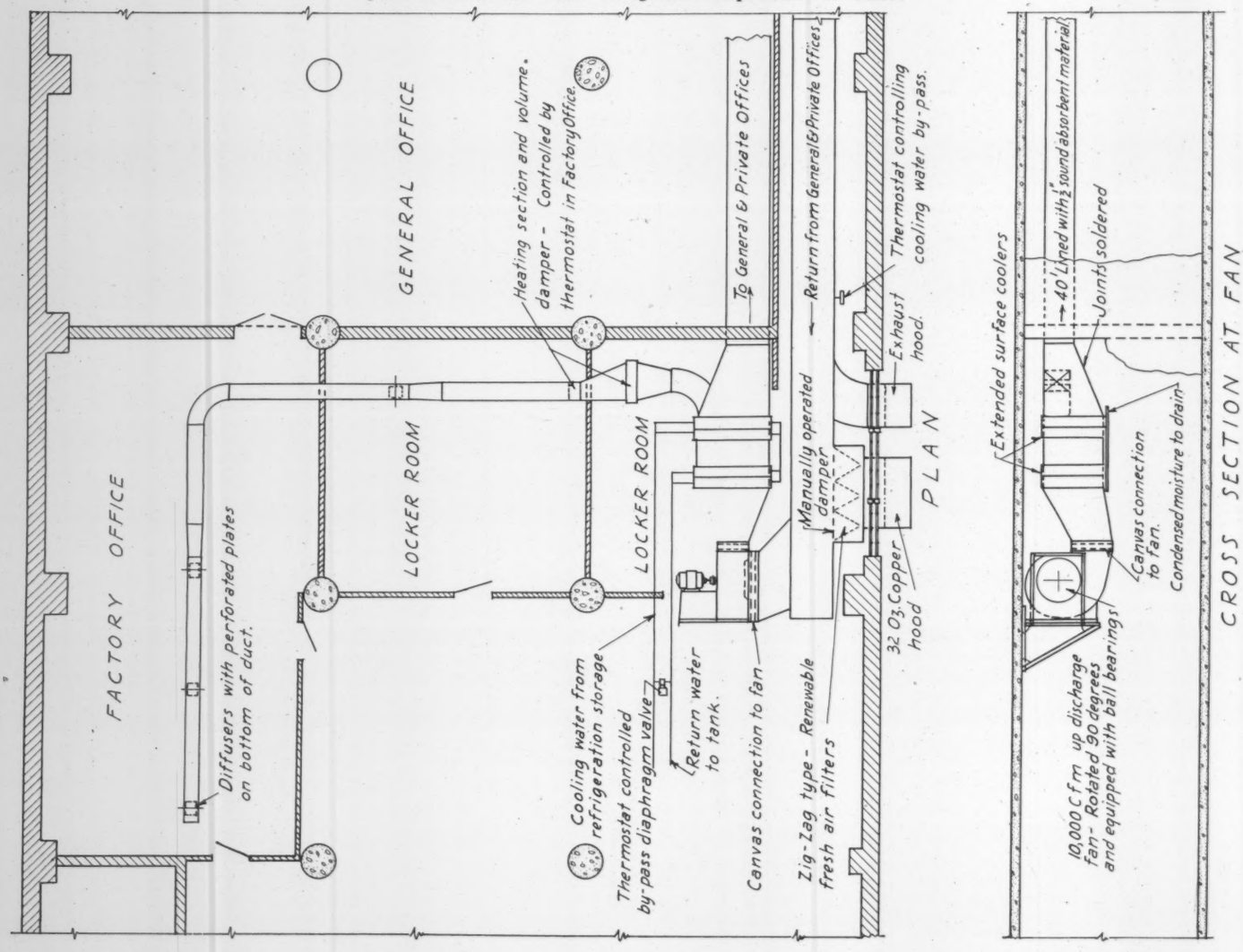
Relocation of Equipment—Conditioning systems for some individual areas have been relocated on the ceiling to release usable floor space (see sketch). An example is the rearrangement of the fan, coolers and filters for the general and private offices. Incidentally, this particular system was originally arranged with the surface coolers on the suction side of the fan. The cooling effect is now in the path of the air leaving the fan and the fan heat can be absorbed by the cooling surface, setting up a greater differential between the cooling air and the office temperatures, with the same refrigerant temperature as before.

Entrained Moisture—One of the major problems in cooling this space is the removal of considerable amounts of latent heat produced by infiltration from the adjacent manufacturing areas which are held at 70 per cent relative humidity. Since a comparatively large amount of water is extracted from the air to obtain the required relative humidity in the offices, it was felt that a blow through system might cause entrained water to leave the coolers and pass out into the duct system, resulting in undesirable dripping in the conditioned space. To preclude this possibility, the air velocity through the surface was held to 400 fpm and a long drainage section was provided on the discharge side of the cooling surface. This has been entirely satisfactory even with the cooling water at its lowest temperature of 40 F. The system is served by stored refrigeration, as previously described.

In a new program, the air velocity through one of the central station humidifiers was increased to approximately 750 fpm. As expected, entrained moisture was then observed leaving the eliminators. As it was impossible to reduce the velocity by increasing the cross-sectional area of the humidifier, this was corrected by installing an 8 mesh per in., 20 ga copper screen in the humidifier chamber directly in front of the eliminators. There has been little perceptible change in the static resistance of the humidifier and the difficulty with the entrainment has disappeared completely. This same device has been employed satisfactorily where the amount of water handled in a spray chamber was increased and it was inconvenient to add more deflecting and impingement surface to the eliminators.

Air Delivery—The distributing ducts originally in-

Rearrangement of equipment for general and private offices on the ceiling released usable floor spaee. Surface coolers are now on the discharge side of the fan to absorb fan heat, setting up a greater differential between cooling air and office temperature with the same refrigerant temperature as before


GENERAL OFFICE
FACTORY OFFICE
LOCKER ROOM
LOCKER ROOM
Heating section and volume damper - Controlled by thermostat in Factory Office
To General & Private Offices
Return from General & Private Offices
Thermostat controlling cooling water by-pass.
Exhaust hood
Manually operated damper
32 Oz. Copper hood
Diffusers with perforated plates on bottom of duct.
Cooling water from refrigeration storage
Thermostat controlled by-pass diaphragm valve
Return water to tank.
Canvas connection to fan
Zig-Zag type - Renewable fresh air filters
PLAN
Extended surface coolers
40 Lined with 1/2" sound absorbent material
Joints soldered
Canvas connection to fan.
Condensed moisture to drain
10,000 C.f.m. up discharge fan - Rotated 90 degrees and equipped with ball bearings
CROSS SECTION AT FAN

stalled for the manufacturing areas delivered the air horizontally from a central main through low pressure diffusers at approximately 500 fpm. In a number of instances this arrangement has been changed to use the same diffusers placed on the bottom of the duct, with suitable perforated deflector plates. Where necessary, additional branch ducts were run out from the central position to provide for proper distribution. The obviously more direct and efficient effect of air delivery in this manner has been of decided value during the months when cooling and dehumidification are required. This is particularly true where the ceiling above the conditioned space has a higher surface temperature than the area in the room, as occurs under processing chambers and the roof.

Conditions Maintained—Determination of the proper air conditions to be established in the manufacturing areas provided an interesting study. The original thought was that 70 to 72 F dry bulb would be suitable. It soon became evident, however, that due to the rapid air movement and other factors, so low a temperature was not desirable. A satisfactory level has been established at 77 F dry bulb during the winter months and a range of 77 to 80 F during the summer when cooling is used. At the standard relative humidity of 70 per cent this corresponds to wet bulb temperatures of 70 to 72 F and, naturally, lowers considerably the refrigeration load over the original calculations. Incidentally, 77 to 80 F dry bulb, with relative humidity of 45 to 55 per cent, is most desirable for the offices.

Life and Construction of Equipment

The following table of estimated and determined life of certain parts is based on observation of this equipment and that in our other buildings. The duty is in each case continuous—24 hours per day:

Part	*Recommended Material*	*Maintenance Schedule*	*Probable Years of Life*
Humidifier tanks	Galvanized iron, hot asphalt coated inside	Re-surface every 3 years	15
Humidifier casing	Galvanized iron, hot asphalt coated inside	Re-surface every 2 years	15
Humidifier piping	Galvanized, copper bearing pipe	Paint every year	20
Humidifier eliminators	Galvanized—dipped in hot asphaltic solution before erection	Paint every year	8
Orifice caps	Brass, chromium plated		2
Fan wheels	Galvanized iron	Paint every 6 months	10
Fan casing	Galvanized iron	Paint every 6 months	15
Fan inlet cone	Galvanized iron	Paint every 6 months	5
Condenser tubes for refrigeration	Admiralty metal or copper lined steel		15

It has been found advisable to use corrosion protected metals for fan, wheels, housings and inlet cones with all draw through humidifier systems. Due to their usual inaccessibility, special care must be taken to insure proper cleaning and painting of eliminators. The humidifier casings, as constructed of galvanized iron and coated with hot asphalt, have not shown evidence of corrosion. The tanks, however, developed pin hole leaks after approximately one year and were then resurfaced with a hot asphaltic coating approximately ½ in. thick. With the water available, steel condenser tubes required yearly replacement. Distributing duct maintenance has not presented a serious problem, and no deterioration has been evident. It is our definite impression, established from service records of over 50 units and central stations, that it is not economical to economize on original installation by using black iron or the lighter gages of galvanized metal for any portion of an air conditioning system. In each case where such materials were used, early replacement was necessary. In general, major repairs and replacements have not been required. It is estimated that less than 1 per cent of the original installation cost is an ample yearly allowance for maintenance work on all portions of the system.

Building Insulation and Double Sash

The much discussed insulated building performs its function admirably.[2] Two inches of cork board provided for all exterior walls and roof prevents condensation perfectly whenever applied over brick and tile. On concrete beams and columns, however, where the concrete extends directly to the exterior, a greater thickness or local heating is required. It has been noted in process rooms carrying a high dew point differential that cracks in the plaster surface permit condensation to enter the cork structure, causing early decay. Tests have shown that for this type of service a plastic sealing surface is advisable. This may be impregnated into the sheets before erection or applied as a finish coat, and is preferably of asphalt emulsion or similar material. Routine inspections are made to locate exposed cork in order to permit local repair before moisture enters in a serious degree.

At the temperature and dew point levels carried in this manufacturing practice, the advantages of complete insulation are decidedly apparent and need no comment here. Also, the possibilities of indirect heating, economy of fuel, close control of atmospheric conditions and productive use of all floor space are due in large measure to the insulation. Since the erection of this building, all construction carried on by Bayuk has included thermal protection.

The experience with double fixed window sash has been interesting. Due to the high dew point carried, it was necessary to run steam coils made up of 2 in. pipe along the sill between the sash to eliminate condensation under low temperature extremes. The economy of double sash has been quite evident. In some office areas, however, window openings were later installed principally for psychological reasons.

A number of increases have been made in tobacco processing and storage, many of which required refrigeration. For these services, ammonia systems have been installed in the basement of the building so grouped as to the required temperature of cooling mediums that two large systems, one delivering water at 45 and one at 55 F, distribute the refrigerating effect to the nine enclosures in which cooling is required. It should be pointed out in this connection that the advisability of

[2] "Insulation Decreases Load on Industrial Air Conditioning Plant by One-Third," by R. D. Touton, HEATING, PIPING AND AIR CONDITIONING, June, 1931, pp. 453-457.

ample storage for intermittent refrigeration systems and of off peak operation has been clearly demonstrated.

Water Treatment Prevents Sludge Formation

Large volumes of air are constantly withdrawn from the cigar making machines by the suction system holding the leaves in place for the rolling operation. This air is then passed through filter type dust arresters and returned to the humidifier for reconditioning, and a considerable amount of sludge is formed in the humidifier tanks. At the end of a week's operation, the services of two men for six hours were required to clean thoroughly the casing tank, eliminators, nozzle and piping systems. More serious than this, however, was the progressive diminishing of saturating efficiency as the nozzles became clogged toward the end of the operating week.

Attempts were made to discover a suitable water treating agent which would prevent the formation of this sludge, but the early experiences in this connection were disappointing. A satisfactory treatment has now been found, however, which practically eliminates clogged nozzles and maintains the correct pH value in the recirculated water. Total cost of the treatment is less than the cost of the former manual cleaning, with the additional advantage of constant air saturation.

Too great stress cannot be laid on the careful operation of air conditioning. To insure this, the designer should be doubly careful to avoid complicated, over-delicate controls and superfluous gadgets. A number of new devices have been developed for our application in some of which the permissible variation is less than $\frac{1}{20}$ F, and a total of more than 50 controls are in service, but it is our impression that strong emphasis should be placed on ruggedness and simplicity. This is the only method of avoiding possibility of operating error and interference to service.

Cost of Air Conditioning

A condensed but illuminating method of estimating the value of air conditioning is to divide the cost of daily operation by the number of operators. In so doing, we arrive at the important fact that the total fixed and operating costs of all the systems, including processing, are equal to less than 3c per operator per day. A similarly significant condition is observed when the above costs are compared to the total pounds of tobacco handled. It is then determined that, per pound of tobacco, the air conditioning cost is less than $\frac{1}{4}$c. In this consideration, it must be remembered that the tobacco does not travel through the building rapidly but that material is always in process for three months' production.

There can be no question but that full preservation of the inherent goodness of the costly tobaccos—traceable directly to the use of complete air conditioning—and the more accurate workmanship and greater productivity of highly skilled labor are reflected in a degree which returns these small costs many times over. Experience is always the conclusive test of value. Excellent opportunity has existed and is constantly present for critical observation and, fortunately, it has been possible to make alterations and incorporate new methods immediately as required to meet changing production schedules and manufacturing procedures.

In summary, we find that this air conditioning application provided a basis for smooth operation at once. Now equipped with 500 hp of motor capacity and circulating 300,000 cfm of air in seven distinct classifications of duty, it is meeting the production demands of the largest selling cigar in the world. It conditions the space used daily by more than 4,000 people and prepares the atmosphere in the manner best suited to comfort and efficient production without regard to weather fluctuations. It has been demonstrated beyond doubt to be an important and remunerative production tool and, more than any other, serves to hold all manufacturing components in perfect balance. The often expressed consensus is that the system, with its flexibility and its many purposes, serves its owner consistently and well.

Pioneer User Says Air Conditioning Pays

Widely publicized when opened in February, 1928, as the first air-conditioned office building, the 22 story Milam building, San Antonio, recently was sold at public auction. This, however, does not mean that the building with its innovations (it also was at the time of its construction the tallest reinforced concrete frame building) has been a failure. The truth is, according to Manager M. A. Snyder, that during years of the depression the Milam has enjoyed a higher occupancy percentage than the average Class A structure in San Antonio, and today its obsolescence is less because of air conditioning.

Mr. Snyder, summing up the Milam's experience with air conditioning, said: "We have found it expensive, but the expense has been justified." To support his conclusions he has collected testimonials from many tenants. Following are a few of them: "Offices are worth 50 per cent more with air conditioning." "Thirty per cent more efficiency in the Milam building." "Be willing to pay $20 to $30 more per month for same office space—makes work a pleasure." "My rooms are like springtime, an ideal atmosphere." "It means an increased number of visitors during the hot summer months."

Air conditioning solved a generally difficult problem for the Milam in that it has profitably rented a large area of its basement to a cafe practically ever since the building was completed. The management has estimated that in normal times the revenue from basement space is increased, by reason of air conditioning, about 50 per cent and on other space 10 to 35 per cent. Air conditioning also enabled omission of direct radiation ceiling fans, and transoms for ventilation. Further savings are effected in cost of cleaning and painting because windows can be kept closed. This system was described in the July, 1929, H. P. & A. C.

ESTIMATING PIPING

—*Method Outlined, Principles Explained*

By **E. W. Norris**

AN estimate is a prediction of a cost. For this reason the operations of estimating and cost keeping have much in common and estimating is made clearer and more convenient by arranging the work with this in mind. Actual construction is started with plans and lists of requirements. This is followed by the purchase of material and the labor of construction. Finally the costs of material and labor are brought together, overhead is added and the cost is completed. For an estimate, therefore, there must be plans and lists of material. Following these instead of actual purchase, comes a compilation of prices and in place of actual construction, an estimate of the labor required, and of overhead. To the items that naturally come to mind as directly used in this connection there must be added the others that so often upset otherwise excellent estimating work. These comprise the contingent items, such as erecting scaffolding, moving interferences, changing and repairing existing structures, cleaning, and such others as may arise but are apt to differ widely from one job to another. To compile a good estimate requires experience, but much can be done by proper preparation of data and the collection and use of information easily available.

The Plan

The work to be estimated must be shown on some form of plan. This may comprise complete detail drawings with explanatory specifications, or at the other extreme may be a simple flow diagram on which pipe sizes and brief service requirements are noted. In either case there must be sufficient data for the listing of all the material required with the proper sizes and service conditions. There must also be information regarding the locality and general working conditions so that the estimator can form a good idea of the methods to be used in actual construction. For most estimates the simpler plans are sufficient, especially if they indicate the features of the system in its more important details.

List of Material and Costs

The list of material can best be arranged on a definite form which may be printed or may be simply penciled on the work sheets. The important information required includes the name of the piece, its brief description, class and size. These headings should be followed by columns for list price, discounts, net price, and finally for quantity and total price. Freight may be added, though this is usually handled as a separate addition to a group of items

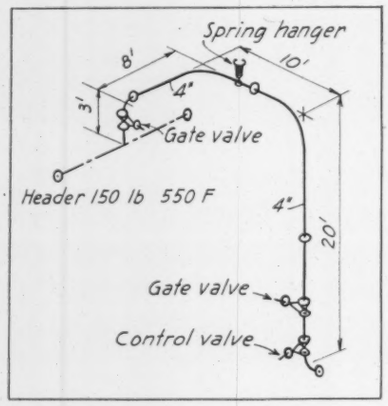
When the material is listed, the cost of each item must be filled in. For costs it is necessary to have available catalogs and cost sheets covering the class of work to be done. The catalogs of the larger supply houses can be relied on for accepted list prices of material such as valves and fittings. Pipe may be included in these, or may be shown on a separate "pipe card" giving net prices. Hangers and erection details are frequently covered in separate catalogs. Such items as pipe bending and flanging and the welding of standardized forms are now listed by the larger fabricators and prices and discounts may be obtained in catalog form and used with the same certainty as those for fittings. Price information must be accompanied by corresponding discount sheets so that net prices may be figured. Weights are rarely shown in catalogs but should be obtained where required for estimating transportation costs and, in some cases, erection costs. In using prices it is sometimes necessary to distinguish between factory prices and stock prices. Especially with some grades of pipe, a slightly higher price must sometimes be paid for material from warehouse stock.

A matter that should be kept clear is the changing designations of piping materials. For many years the piping trade recognized "standard", "extra heavy" and "double extra heavy." These, with such specialties as ammonia and hydraulic material, made up the list. The wider use of steam and processes at much higher pressures and temperatures has resulted in an entirely new series of pressure classes beginning at 150 lb and going up to 1500 lb. These various classes are clearly shown in the catalogs but usage has not yet made them sufficiently familiar to prevent misunderstandings in interpreting specifications.

This outline of the procedure for estimating piping has been prepared in answer to a number of requests from readers of H. P. & A. C. who have been able to find but little published data on this important subject..... Intended primarily for the beginner rather than the experienced estimator, and especially for men in relatively small organizations where such information is not readily obtainable, the various items of an estimate are explained, an example is presented, and the principles of estimating are discussed..... A second article is contemplated which will give suggestions for working up preliminary information such as must be available before estimating is commenced

Cost of Labor

The cost of labor cannot be itemized in the ordinary sense. On larger work this cost fortunately forms a reasonably uniform ratio to the cost of materials, and can therefore be handled as a percentage to be added to the total material cost. Naturally, this percentage will vary with the character of the work and the selection of the proper value forms an important part of estimating which must be based on experience and for which no price list can be arranged. The novice must depend on advice for this item until he has accumulated sufficient experience and cost data to bring his guesses into the "educated" class. Fortunately it will be found that the general trend is fairly easy to grasp and reasonable approximations can be arrived at after relatively little estimating work. The percentage of labor will be low for fabricated piping where little more than assembling is done in the field. For work where fabricating is largely field work, which usually includes work done in field pipe shops, the labor is higher. This does not always mean that the total cost is higher because the cost of shop fabrication is correspondingly reduced. For general miscellaneous pipe work the labor cost can be assumed to run from 30 to 50 per cent of the total cost of materials. Very small work sometimes runs up to 100 per cent. Instrument piping may be more or less, depending on its character. These figures are intended to convey the roughest idea of the general relations that may be expected and of course should not be used on actual work without checking with cost data.



Sketch of turbine lead used as example of method of estimating

For welded piping the labor problem is quite different. Nozzles, branches, and all reasonable fabrication is done in the shop either of a fabricator or in the field. The actual erection includes the placing and welding of the main joints. Costs for the several types of welds can be approximated from fabricators' catalogs and from general welding data. Here again actual cost figures are of prime importance; no important work should be undertaken without them.

For the very small jobs it often is unsafe to estimate labor as a percentage. A more reliable prediction of cost can usually be made by summarizing the actual work to be done and forming a mental picture of the time and number of men required to do it. This should be reduced to "man hours" and priced by the payroll; to the total payroll should be added the proper overhead for the labor involved. Actual experience in piping work is of the greatest value in judging costs in this way.

As implied above, the cost of labor overhead is usually included with the labor item. Additional overhead not directly connected with the labor may be cared for as a percentage or estimated separately, and included under such headings as Purchasing, Field Office, Engineering, and so on.

Example Shows Use of Suggestions

The following example gives a practical application of these suggestions. In order to focus the attention on the method rather than on prices and values, *these latter have been intentionally distorted* and should not be considered typical.

It is assumed that a steam lead is to be run from a header to a small steam turbine; the layout is shown in the sketch, which is of simple isometric type but shows all the essential parts. The dimensions and notes give such additional information as is required for selecting the proper sizes and types of material for the service. A spring hanger is shown, one being sufficient for this relatively simple line. The control valve is shown as an indication of the special items that are often included in this work.

The estimate is shown by the table. First the material is listed, taking it class by class and working along the pipe to avoid overlooking any items. The list prices are taken from catalogs and the discounts are noted. Then the net prices and the total prices are figured and totalled. Items like the control valve will not be found in the usual piping catalogs, so prices for such items must be obtained separately from the manufacturers and added to the regular piping material. The spring hanger also is included as a separate item.

The freight is estimated from the total weight, which may be summed up separately or shown on a column directly on the estimate sheet. If the several items or groups of items are to be brought from widely differing localities, it is necessary to estimate the freight on each separately and add the total.

It is assumed that this piping has been completely shop fabricated from a properly prepared drawing and that therefore it is necessary only to place the parts and make up the joints. For this reason, labor is estimated in man-hours, making allowance for the part that must be done on Sunday. Overhead, in this case, is figured as a percentage on labor.

Covering is usually separated and should be estimated in detail in the same general way as the piping. The total is added to the cost of the piping erected.

As examples of extra and contingent items which must always be anticipated it is assumed in this case that a wall must be cut and repaired to provide an opening for the branch pipe, and also that an electric light must be moved to clear the new work.

The total thus obtained is the prediction of the cost of doing the actual construction. If plans are to be included, they must be estimated separately. For an organization doing work with its own forces this usually completes the cost, but if it is to form a contract the contractor's office overhead and profit should be added.

Method Same for Larger Jobs

The example given is a very simple one. For more complicated piping systems the method is the same except that it is expanded to suit the more elaborate work and the numerous items. The work of preparing such

an estimate is simplified by preliminary planning. The several systems are separated and each analyzed into its main and secondary lines. Wherever possible, the estimator should take advantage of duplicate lines to reduce the work of itemizing.

In large systems the fabrication is often divided between shop and field work and this division can usually be anticipated by studying the general features of the various lines. Shop work can be estimated by using the unit costs for different items of shop fabrication work as previously mentioned. Field labor is a part of erection and the "percentage of material" method of estimating labor usually fits this work well if the percentages are carefully worked out and based on records of reasonably similar constructions.

In the large systems, the items of associated work and contingencies are particularly important. On new construction there is always the chance of interference from other parts of the work and the disarrangement of schedules by late deliveries and other delays. Where pipe lines and systems are to be installed in open country, provision must be made for the delivery of material and construction equipment at the site and for the peculiarities of the weather at the time of erection. If the new construction is to be installed in existing buildings, even more careful surveys of the site must be made before estimating because interferences may introduce particularly difficult construction methods or may involve expensive removal costs; this is most important in underground work. Another matter that requires careful inspection is the strength and stiffness of structures relied on for support, not only for the finished work, but during construction as well. These may need temporary or permanent strengthening. Here again supply of material must be looked into, as close clearances or weak substructures not infrequently require use of special construction to permit passage for the work.

These notes on estimating are intended for the assistance of the less experienced estimator to whom the subject presents itself as something of a mystery. For this reason several points are covered that may appear unnecessary but which have proved to be matters of uncertainty to many. The article is intended to supplement practical experience on the part of the estimator and his associates and suggest methods of using this effectively with catalog costs. In estimating, more than in most activities, genius is the capacity for taking infinite pains. A few fortunates can very closely approximate costs by a subconscious use of long experience, which seems like pure guesswork to the uninitiated. As a rule, however, these guesses are the result of infinite pains expended in the past. For the majority, the safe plan is the more tedious one of making use of every available source of information and a conscientious attempt to fill in the blank spaces by outguessing the future.

Estimate for Turbine Lead

Main Steam System 150 lb 550 F

Item	Kind	Class	Size	List Price	Discounts	Net Price	Quan.	Total Price
Valve	Gate	Fl. OSY	4	$115	25+10	$78	1	$ 78
"	Globe	Fl. OSY	4	115	10	104	1	104
"	Control	Diaphragm	4	——	——	150	1	150
Ell	Short Rad.	Fl.	4	22	40+10	12	2	24
Bend	90°	10 Dia. Rad.	4	25	50+25	10	2	20
Flanges	Van Stone	Raised Face	4	25	50+25+10	9	9	81
Pipe	Std.	Lap. Wld.	4	1.50	40	0.90	40	36
Nozzle	Welded	Fl. 90°	4	21	40+25+10	9	1	9
								$502

Spring support		$166
Labor:		
Apply nozzle to 12 in. main, Sunday, Man & helper, 4 hr @ double, 8 hr @ $1.75		$14
Erection	12 " @ 1.75	21
Placing	4 " @ 1.50	6
Supervision		5
		$46
Overhead @ 100%		46
Total Labor		$ 92
Freight and trucking		80
Erected Cost		$790
Covering in place		80
Cutting and patching wall		12
Moving electric light		8
Total Cost		$890

[*Note*—Prices have been intentionally distorted, but give general application of method.]

[*Continued from page* 13]

72 per cent was the figure upon which the analysis preliminary to the change-over was made.

Fifteen Men Operate, Maintain Heating and Air Conditioning Services

Heating, piping and air conditioning engineers will find the Palmer House of unusual interest in many other respects. Although but few people stopping at a modern hotel realize the extent of the heating, piping and air conditioning services probably no other class of building utilizes them to any greater measure. For instance, 15 men are required to operate and maintain the heating and air conditioning equipment at the Palmer House; an average of 800,000 lb of steam are required per day for heating; 1200 tons of washed air are supplied per hr; there are 300 tons of refrigeration capacity for air conditioning; 650 tons of sheet metal duct work—entirely concealed, a feat in itself; and 375,000 sq ft of equivalent direct radiation.

This hotel has been using air conditioning for its public and private dining rooms since 1925. There are 31 supply and 35 exhaust fans whose combined capacity approximates 1,100,000 cfm. Most of the supply fans and the reinforced concrete air washers are in the subbasement; others are on the 5th and 24th floors. The exhaust fans are on various floors, discharging either to the roof or to the boiler room to maintain reasonable temperatures the year around and to supply air for combustion.

The engineering department of the Palmer House has always given close attention to pipe fabricating methods, has employed both arc and gas welding for many years, and was one of the first organizations to use welding fittings.

The courtesy of Mr. J. E. Hill, Superintendent of the Palmer House, Mr. P. H. Mahoney, Mechanical Engineer, Mr. E. D. Benton, Combustion Engineer, and Mr. Norman Douglass of Thomas J. Douglass & Co., who were the contractors for the gas and oil change-over, all readers of H. P. & A. C., in cooperating in the preparation of this article is gratefully acknowledged.

Keeping the Heat Out of Treated Space Leads to Economy in Air Conditioning

By **Lester T. Avery***

WHEN an existing room is surveyed for summer cooling and dehumidifying it must be accepted as built and the necessary air conditioning equipment applied to it. In many cases the room is suffering from excess heat which may to a certain extent be controlled or prevented. Good engineering requires study of these sources of heat to determine if it is more economical to block it away from the treated space, or if refrigeration equipment shall be increased in capacity to produce the required results.

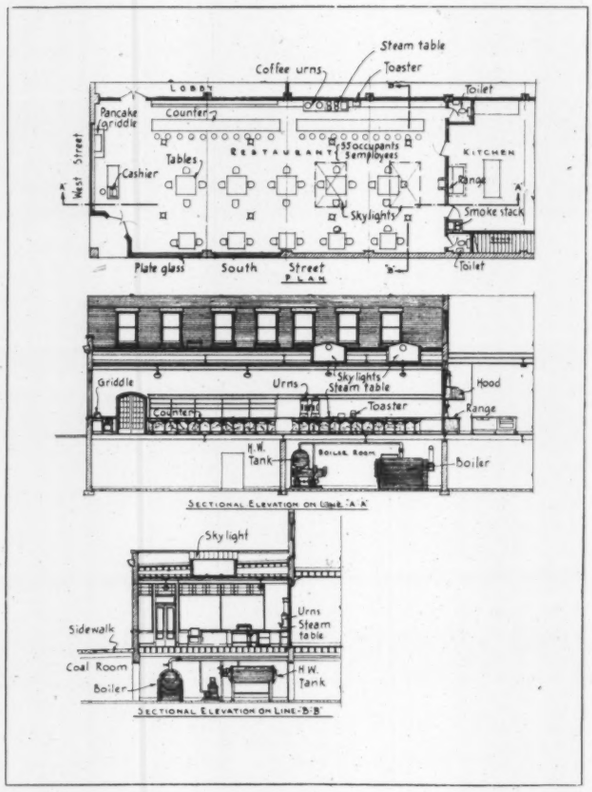
All buildings suffer from undesired sources of heat at certain times. Offices and residences are often overheated from sun rays; rooms may be overheated from steam pipes passing through to rooms on higher levels, even though these pipes are behind walls; a hot chimney has often caused overheating where it passed near occupied quarters. Not only must the space which is to be air conditioned be surveyed but the surroundings must also be checked. What is the space used for which is above and below the treated space and at the sides, and what is the construction of the barrier between? Many disappointments have come with the installation of summer conditioning because one or more such factors have been overlooked. The following paragraphs emphasize the importance of a complete, careful survey with the idea of making such changes in the building as are economically sound before applying summer air conditioning equipment.

Restaurants Are Greatest Offenders

The restaurant is probably the greatest offender in having undesired heat sources. The sketch is a floor plan and sectional elevations of a restaurant which is a composite of two restaurants surveyed; undoubtedly there are single restaurants in operation which have all of these heat producing sources so that the example is not necessarily an exaggeration. The individual factors may occur singly or in combination in present structures to a greater or less degree.

The restaurant under consideration is on the ground floor corner with the building set back above which permits the sun to beat directly on the roof. It faces south and west with glass windows on both sides and the entrance at the corner. The boiler plant for the building is in the basement, and partially under the restaurant. The building construction is ordinary, as found in many older buildings, and the coffee urns and steam tables were installed with relation to service, and with no provision for removing steam or heat.

The restaurant has 5 employes and seating capacity for 55 patrons. In the show window on the west side



Plan and elevation of restaurant used as an example to show how treatment can reduce required capacity of air conditioning equipment

there is an open pancake and waffle grill, or possibly a doughnut machine. The kitchen range is directly against the dividing wall between kitchen and restaurant, hooded, to be sure, but not thoroughly insulated, so that the wall behind the range is warm. Also, the stack from the boiler comes up in a corner with one side against the restaurant wall.

Table 1 shows the various heat sources, first for the restaurant as it exists and second after the application of corrective treatment. In setting up the recommended treatment the author has endeavored to stay within minimum economic limits; further reduction in the heat gain could be secured by more thorough insulation or other changes involving somewhat more cost. These factors should be considered and discussed with the owner, and he may be encouraged to do all of these things and to do some of them in a better way than outlined in the table. Various considerations are involved, including the important one of whether the space is owned by its oper-

*President, Avery Engrg. Co., Cleveland, Ohio.

Study of heat sources when a space is being surveyed for summer air conditioning and proper treatment to reduce or eliminate excessive heat gains is required for economy in the first and operating cost of the equipment. Because restaurants are perhaps the greatest offenders in having undesired heat sources, the author considers an example here, shows how the application of insulation and other corrective measures can reduce the necessary cooling capacity to nearly half that otherwise required. The same principles outlined for this example apply as well to other types of conditioned spaces.

ator who is paying for all changes to the structure and all operating costs and will continue to use the space for many years, or whether the space is leased or may be converted to other uses within a few years.

The author is reminded of a discussion with an owner three years ago who first considered summer conditioning in a new restaurant of fairly large size which was to be equipped with two double batteries of 10 gallon coffee urns. Other restaurants in this same chain had these same coffee urns directly accessible to counters and tables, arranged for the shortest travel between service and urn by the waitress. The owner had no sympathy whatever with the suggestion that the urns be hooded, as this would spoil the open effect of the ceiling and would require hoods dropped down in the center of the room which would be unsightly no matter how ornamental in finish or construction. He was very definite in stating that there was absolutely no other place to install the urns which would be equally serviceable from a restaurant efficiency standpoint. Three years' experience with summer air conditioning has so changed his point of view that his restaurants now have coffee urns in alcoves off the dining space proper and provided with hoods and positive exhaust fans. Not only is the heat and moisture removed, but the appearance of the restaurant is improved; and while it may require a few more steps for the waitress to secure the coffee and deliver to the table, the patron is willing to wait because he sits in an atmosphere of comfort and is not in such a hurry to get out on the street where "the air is better."

Methods of Reducing Heat Gains

The items of Table 1 are discussed briefly below to explain some of the problems and suggest solutions not incorporated in the table. The coefficients of heat transmission and other factors used are from the *Guide* of the *American Society of Heating and Ventilating Engineers* and other reputable sources readily available, and are therefore not repeated here.

Venetian Blinds and Awnings—The west wall is mostly window and the brick portion below and above the window and at the sides is accepted "as is" with no recommended change. The west show window may be protected with awnings. Outside venetian blinds are even better, as some owners object to the fire hazard of the canvas awnings. If the owner objects to any outside sun protection, venetian blinds may be used inside, preferably aluminum coated, and maintained at an angle always to reflect sun rays outward rather than inward. The conventional venetian blind arrangement is generally unsatisfactory, as the manager insists on maintaining the vanes horizontal to permit light to come in and patrons to see out. In this position the vane redirects the sun rays into the room and the heat gain is as great as if there were no protection. Even with the vanes closed the blind acts as a "panel heater."

Wall Insulation—The south wall has show windows about halfway back and brick the balance. Any insulation treatment on the brick would have to be done inside and if the owner would consider general interior redecoration, an air space with insulated plaster base or wood paneling would be worthwhile. The brick will

Table 1—Heat Gains to Restaurant Before and After Application of Corrective Treatment

Surface or Medium From Which Heat Gain is Obtained	Heat Gain in Btu per Hr Without Insulation, Awnings or Other Heat Reducing Equipment		Heat Gain in Btu per Hr Using Insulation, Awnings, Hood Exhaust and Other Heat Reducing Equipment		Types of Insulation and Other Methods of Reducing the Heat Gain
	Sensible	Latent	Sensible	Latent	
West Wall—Sunlit	1380	.....	1380	.....	No insulation.
West Glass	2440	.....	2440	.....	Awnings.
South Wall—Sunlit	4685	.....	4685	.....	No insulation
South Glass	3660	.....	3660	.....	Awnings.
Entrance Wall—Shaded	330	.....	330	.....	Shaded.
Entrance Glass	1550	.....	1550	.....	Shaded.
Roof—Sunlit	33310	.....	6245	.....	4 in. rockwool fill.
Floor Over Boiler Room	9330	.....	1645	.....	4 in. rockwool fill.
Inside Wall, Lobby, Toilets, Stair	6210	.....	6210	.....	No insulation
Kitchen Wall	1520	.....	175	.....	Rockwool fill.
Wall Back of Range and Smokestack	2635	.....	405	.....	Aluminum foil and rockwool fill.
Skylight	595	.....	595	.....	No insulation.
Sun Load—West Glass	28800*	.....	3600*	.....	Awnings.
Sun Load—South Glass	35305	.....	7655	.....	Awnings.
Sun Load—Skylight	21120	.....	10800	.....	White shade.
Lighting	None	.....	10200	.....	Lights used with awnings.
Steam Table	7200	36000	3600	18000	Hood exhaust.
Two 10 Gal Coffee Urns	8000	8000	4000	4000	Hood exhaust.
Waffle Griddle	20000*	.....	10000*	.....	Hood exhaust.
Toaster	8500	.....	4750	.....	Hood exhaust.
People	13200	10800	13200	10800	.....
Food	4200	.....	4200	.....	.....
Total	213970 48800*	54800	101325 13600*	32800	
Load	165170		87725		
Total Cubic Feet of Air per Minute to Cool with 20 F Rise	7735		4100		

*Omitted from total as these loads do not occur at the same time as other loads

absorb the heat from the sun and the wall temperature will lag about 4 hr behind the sun. If uninsulated, the south brickwork will add its heat to the room by "panel heating" in the late afternoon at the same time the west wall and window are getting the maximum sun heat. This is the same time the restaurant should be most attractive to those who wish a comfortable dinner after a hot day's work. There is an additional important reason for wall insulation, aside from the saving in heat transmission, and that is that any patrons sitting near the wall may be very much overheated from the radiant effect of "panel heating" even though the air temperature at that point is sufficiently low to be considered comfortable. The treatment of the south glass window is shown for awnings, and the same points relative to venetian blinds apply as mentioned for the west wall.

Ceiling Treatment

Ceiling Treatment—The ceiling (ordinary wood deck with composition roofing, with wood joists and plaster on the under side) is exposed to the sun from early morning until late afternoon. The space between the joists may easily be insulated with a fill material blown in or a layer of insulation placed on top of the roof with new weatherproofing. The roof may be sprayed with waste water from any source; for instance, the condensing water from the refrigerating machine doing the cooling. A simple awning could be erected 5 or 6 ft above the roof as a temporary measure. The skylight can be protected by awnings or with a white window shade. The skylight can be removed entirely and the openings sealed over, as this lighting is of little value.

The ceiling over the boiler room may be insulated with particular attention to breeching, hot water boilers or other hot surfaces which should have reflecting insulation as well as ordinary conducting insulation. The wall between kitchen and dining room may be insulated and, if possible, the kitchen layout revised to allow the range to be against an outside wall. Failing this, good reflecting insulation must be installed between range and partition.

Hoods—No treatment is needed for the interior north wall unless some peculiar use of adjacent rooms indicates high temperatures. Coffee urn, steam table and the grill in the west show window should be hooded. If possible the coffee urns should be placed in the kitchen or in an alcove. Half of the heat is taken care of by the hoods but there is considerable radiant heat which would affect the patrons near the urns. Some restaurants have a battery of toasters, waffle irons, grills, egg boilers, etc., arranged for short orders. Individually these items are not important but the total may be sufficient to justify hooding, or protection from radiant heat striking the patron.

Lighting Load—The lighting will be increased due to shading the skylight and protecting the windows. However, the lighting fixtures should be considered from the standpoint of total wattage against the light required. If a high degree of illumination is desired the fixtures should be designed to give a high lighting effect for minimum current. From a cooling standpoint it is best to use efficient lighting rather than to use bright sources and then cover them up to prevent the light getting out. The entrance should be fitted with double doors to form a vestibule and air lock. This will prevent excessive loss of conditioned air and will improve the comfort of those seated near the door.

Heat Load Cut in Half

Summing up, the reduced heat gains for the items of Table 1 shows that the simply treated space requires about half the cooling that would be required for the untreated space. Obviously the air conditioning equipment will cost less initially and considerably less for operation. Furthermore, it has a reasonable chance of producing successful results. Radiant heat from various sources will defeat the comfort feeling from cool air and if this restaurant were cooled as it originally was surveyed there would be cold spots and hot spots and the air volumes required for cooling would be greater than good practice permits, due to excessive air motion.

Offices, auditoriums, residences, stores, hospital operating rooms and other spaces all have their own peculiar problems of unnecessary heat gains. The air conditioning engineer can perform a useful service by determining what changes are necessary and are reasonable in cost. The air conditioning equipment has an exceedingly long life and any unnecessary heat gain will continuously show in high operating cost. In some installations the heat gain is so excessive that the cooling equipment must be run from early April until late November and may be needed at periods during the winter months. The more effectively the heat is blocked out, the better the outside air can be utilized for cooling effect, and the properly designed system will take advantage of outside air at any time it is below the indoor temperature.

Expansion of Jacketed Pipe Line

THE EDITOR: Referring to the article by G. W. Hauck, p. 527, November, 1935, H. P. & A. C., describing the steam-jacketed piping for heavy oils, is it necessary to provide expansion joints in the 4 in. pipe to compensate for a possible difference of expansion in the run of 2½ and 4 in. pipe?—A. H. (Heating Contractor).

The jacketed line illustrated has been in service for almost two years without any indication of expansion or contraction difficulties. The service is quite intermittent, which makes the operating condition much more severe than if the line were used continuously.

The sections of jacketed piping shown in the drawing published in November are as folloys: *A* is 3′-0″; *B* is 18′-0″; *C* is 12′-8″, and *D* is 6′-0″, the lengths being face-to-face of 2½ in. flanges. An older section of this plant has had a similar system of jacketed piping in service about four years without experiencing any difficulty, in which there are several runs longer than those given above. These longer runs are 20′-2″ and 29′-7″ face-to-face of flanges.

Experience therefore indicates that the method of jacketing piping is satisfactory for long lengths as well as short lengths of piping. Since the 2½ in. and 4 in. pipe are subjected to practically the same temperature, as the steam is in contact with both, the linear expansion and contraction are sufficiently in unison so as not to cause unequal expansion movement. The 4 in. piping was well insulated and water-proofed as an added precaution.—G. W. HAUCK.

Revamping the Building Heating System in the Modernization of Conners Creek

By **Sabin Crocker***

MODERNIZING the twenty year old Conners Creek power house of The Detroit Edison Co., now in process, will continue through several years until all the old 220 lb 600 F boilers and turbines are replaced with modern and more efficient 600 lb 850 F equipment. Since most of the original building structure, canals, stacks, coal handling machinery, condensers and auxiliaries, two 30,000 kw generators, and numerous other items are suitable for re-use just as they were, or with slight alterations, there is a decided incentive to rebuild now while load conditions permit rather than to start an entirely new plant preparatory to scrapping the old at some time in the not too distant future. Many interesting problems have developed in connection with this project,[1] among which revamping the building heating system may appeal to readers of HEATING, PIPING AND AIR CONDITIONING.

A good idea of the size of the job can be obtained from Fig. 1, where the power plant proper with an attached office building at its near end appears in the center, the Essex switching station with its attached control house is seen at the left, and the locomotive and yard crane shelter at the right. All these buildings are supplied with heating steam from the power house through pipe conduits or tunnels which also serve for returning condensate. The amounts of installed radiation and the approximate cubic contents of various portions of the plant are summarized in Table 1.

Heat Emission of Power Equipment Upsets Radiation Computations

Heating a power plant involves several special problems differing from those encountered with other buildings. For instance the presence of hot equipment and piping in some parts of the building with cold condensers and circulating pumps in the turbine house basement upset any ordinary calculation of building heat loss based on wall and glass surface for these portions of the plant. Here it is advisable to temper computed figures with empirical rules founded on experience in other plants. No matter how carefully done, it is unlikely that any computed figures attempting to balance the estimated heat emission of steam equipment and electrical apparatus against infiltration and the wall and glass loss would be reliable within 50 per cent either in a turbine room or boiler house. The difficulty of making such a computation reliable is aggravated by the fact that there is no relation between the severity of the weather and the amount of electrical load carried by the plant, the latter controlling the number of hot and cold units in service. The problem is further complicated by the unbroken ceiling heights (55 and 68 ft respectively) to which both the turbine and boiler rooms extend above their operating floors upsetting the usual methods for computing the required radiation. Since heat supplied at the operating floor level tends to rise and shirk doing its full duty, the problem is mainly

One of the most extensive modernization projects now under way is the rebuilding of the twenty year old Conners Creek power house of The Detroit Edison Co. Because a plant of this kind presents special and unusual problems in the design of the building heating system, the author describes in some detail the manner in which this phase of the revamping is being handled..... An interesting feature is the bleeding of heating steam from the house service turbo-generators and the use of this steam at total temperatures ranging from 315 to 530 degrees Fahrenheit

*Engineer, The Detroit Edison Co., and Member of Board of Consulting and Contributing Editors.

[1] "Welding High-Pressure High-Temperature Steam Piping," by Sabin Crocker, HEATING, PIPING AND AIR CONDITIONING, February, March, 1935.

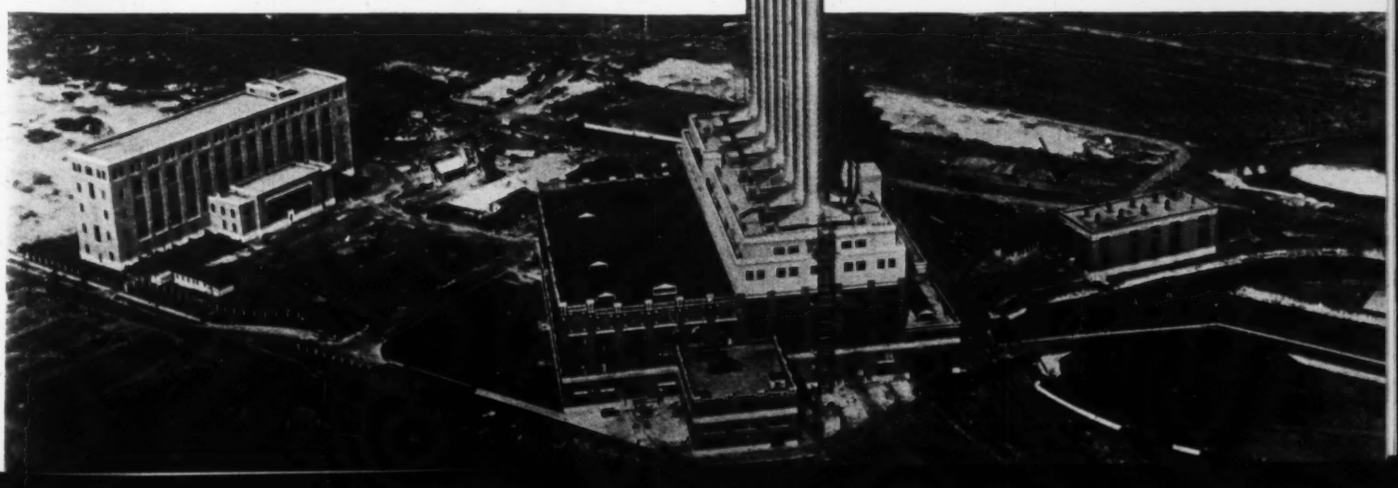


Fig. 1—Conners Creek power plant

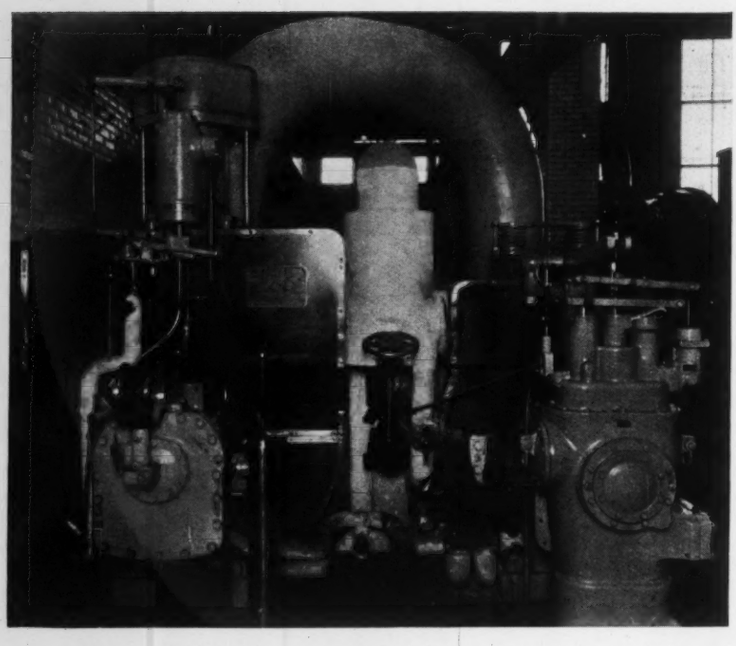


Fig. 2—Head end of cross-compound dc house service unit

one of installing sufficient radiation near the operators to give them a satisfactory sensation of warmth, irrespective of the average room temperature, at the same time partially offsetting objectionable down-drafts at windows and the proximity of large sheets of cold glass. At Conners Creek direct radiation has been largely employed for this purpose, principally because the plant started out that way twenty years ago before either exposed or concealed convection heaters were in extensive use. The final criterion of good design is whether the operating force feels comfortable at all times while pursuing its duties around the plant, and the best guess on this point is founded on experience rather than too fussy heat balance computations.

In the extension at the north end of the turbine house, which will accommodate two additional 60,000 kw turbo-generators, suspended type unit heaters are being used to heat the condenser room and for temporary additional heat during construction in the turbine room. Unit heaters have also been used in condenser hot well pits, isolated shops, etc., throughout the plant. If the Company's engineers were starting afresh without the limitations imposed by the presence of a large amount of old direct radiation, serious consideration would be given to the use of indirect radiation in the turbine room, either in the form of exposed unit heaters or else as concealed forced circulation units placed underneath the windows and at various other strategic points.

There is a time, however, during construction of the plant when empirical rules should be matched against the usual method of computing radiation by estimating heat loss from wall and glass surface plus infiltration. In the case of a turbine room, for instance, fully twice as much radiation may be required during winter construction in the northern United States as would be needed after the equipment is in regular operation. In the case of a modernizing program such as this one, all the equipment at one end of the turbine house will be shut down for alterations while units at the remote end must be kept in use. In a single room having a length of about 400 ft this situation would be conducive toward setting up cold drafts to the decided discomfort of the operating force in the end being used if steps were not taken to counteract this tendency by installing extra radiation ot the end where the equipment is out of service. Sufficient additional radiation has been installed, therefore, in a temporary and inexpensive manner so that it can be readily removed when the plant gets into normal operation. Large size suspended type unit heaters were selected as the best means for providing this temporary heat, particularly since the lofty ceiling dictates that they be placed well up on the wall with their guide vanes inclined downward so as to drive the heat toward the floor.

Heating Requirements in Essex Switching Station

As in the case of the steam power section of the plant certain special requirements must be met in heating the electrical switching station. The relatively small building, shown attached to the front of Essex Station in Fig. 1, houses the control equipment and instruments. A portion of this building is heated to 70 F at all times for

Table 1—Summary of Building Heating Requirements, Conners Creek

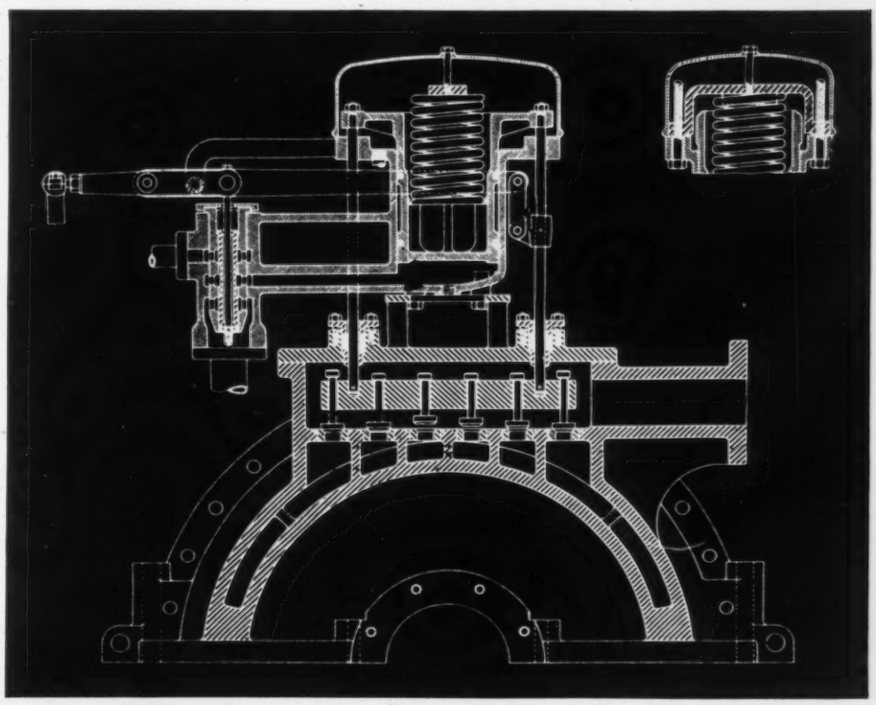
Location	Cubic Contents, Cu Ft	Kind of Radiation	Installed Radiation, Sq Ft 240 Btu	Cu Ft of Volume per Sq Ft of 240 Btu Radiation
Boiler House	5,670,000	Col. and Pipe coil	3,520	1,612
Turbine House	3,500,000	Col. pipe coil, unit heaters	15,034	100
		Blast heaters	20,000*	
Old Switch House	980,000	Col., and Pipe coil	4,983	197
Aux Turbine House, Screen House and Warehouse	540,000	Col. and Unit heaters	6,836	79
Essex Switching Station Main Building	1,880,000	Tube	14,165	133
Control House	185,000	Tube	2,193	85
Office Building, Garage and Screen House	305,000	Col., wall and pipe coil	3,320	92
Coal Unloading House and Shops	720,000	Col. and Unit Heaters	5,028	143
Locomotive and Crane Shelter	310,000	Pipe coil	1,479	210
Scale House and Carpenter Shop	7,000	Col.	300	23
Total	14,097,000	Total Heating	76,858	Average 183
		Max. Ventilating	50,800*	
		Grand Total	127,658	

*Running full blast on zero F outdoor air the theoretical maximum of the blast heaters would be equivalent to 70,800 sq ft of 240 Btu radiation. On the basis of a desired temperature in the turbine house of 65 F, the available sensible heat above that temperature is equivalent to about 20,000 sq ft of 240 Btu radiation. The balance of 50,800 sq ft is chargeable to ventilation. This extreme ventilating load is not expected, however, since the number of air changes can be reduced as the weather becomes more severe.

the comfort of the switchboard operators who make their headquarters there. The main building, which houses the switch gear normally operated by remote control from the switchboard, is patrolled at least once a shift but need not be heated to the temperature required for sedentary office work. In fact it is not necessary to heat this main building at all a good share of the time. While sufficient direct radiation is installed to maintain the temperature at 50 F with zero outdoor temperature, this is not turned on except when actually required for one of the following purposes: (a) in extremely cold weather to obtain a reasonably comfortable temperature for patrol and inspection of equipment; (b) for maintenance or construction work in cold weather; (c) to prevent atmospheric condensation (sweating) on the electrical equipment and walls during the moist weather following a cold snap, as frequently occurs in this climate. The necessity for keeping high voltage electrical equipment of the indoor type dry for safety's sake is of course obvious.

Ventilation for Turbine Room

Some continuous supply of fresh dry air from outdoors is desirable for displacing moist air from a turbine room in winter. The same supply serves for cooling purposes in summer. Arrangements for ventilating the turbine room of the rebuilt plant remain decidedly simple, consisting principally of a fan and blast heaters already used in the plant for many years. The fan has a maximum capacity of 170,000 cfm which is sufficient for about five air changes per hour in the main and auxiliary turbine rooms. This has been found sufficient to carry off the small amounts of moisture now escaping into a turbine room with present effective types of shaft packing. The heaters, placed in stacks four banks deep, are capable of warming 170,000 cfm of air from zero F to 92½ F. This air is allowed to diffuse throughout the condenser room from whence it rises into the turbine room just above through gratings and stair-well openings in the turbine room floor, thus effecting reasonably uniform distribution. Warm air, which has absorbed more-or-less water vapor and risen to the upper part of the turbine room, is drawn off into the boiler house through suction of the stoker fans, by way of openings in the partition wall just below the turbine room ceiling. This circuit works summer and winter to the considerable



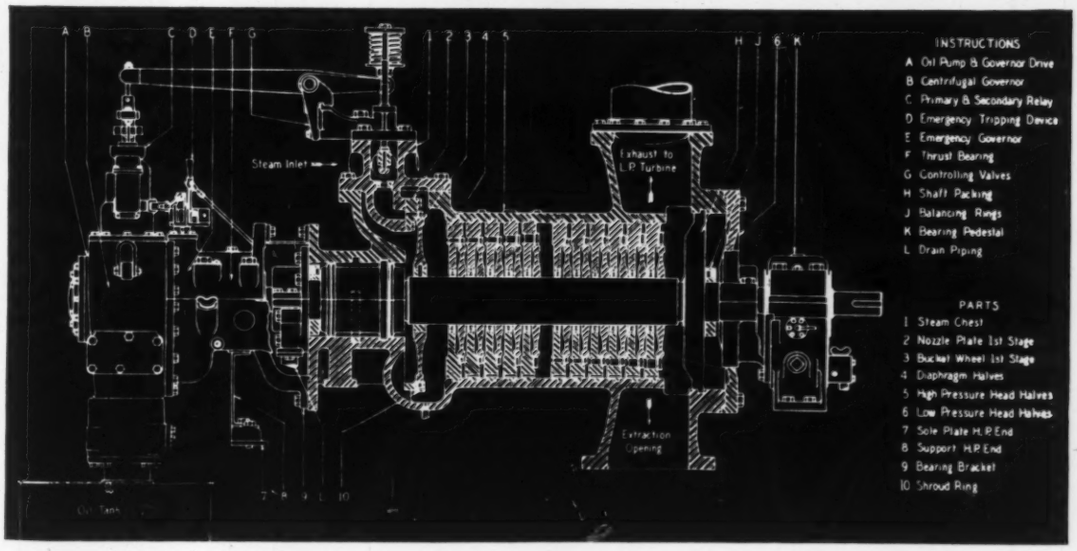


Fig. 3—Sections of dc house service units

(a) Below—Section through high pressure barrel showing crossover and extraction outlet;
(b) Right—Section through steam admission valve of type used on low pressure barrel to control outflow through extraction outlet.

improvement of conditions in both the condenser room and turbine room.

In addition to the *heating and ventilating system* just described there is a small scale *cold air supply system* for ventilating the otherwise over-warm alcove where the 2,000 to 3,000 kw dc house service turbo-generators are located (Fig. 2). Since no closed cooling system is provided for the generators of these units, their electrical losses are given off directly to the turbine room air which is circulated through their windings by fan action. While this affords a welcome source of heat in cold weather, the amount given off in summer, in addition to the radiation from the hot turbine casing and steam chest, is decidedly oppressive and needs to be swept out of the confined auxiliary bay by a liberal supply of cool air, up to 30 air changes per hour being available for the purpose. This air overflows from the alcove into either the boiler room or turbine room, from whence it goes into the stoker fans or out the windows.

Steam Supply for Building Heating

In the modernized plant the normal steam supply for building heating is obtained through bleeding the 2,000 to 3,000 kw direct current turbo-generators used for house service power supply. Since the steam needed for heating purposes thus serves to generate a considerable amount of power under the equivalent of byproduct conditions, this arrangement is more economical than using live saturated steam stepped down from boiler pressure through reducing valves. While a reducing station is available for standby use, it probably will not be required for this purpose after three or more of the new house service units are installed. Due to the variation in stage pressure of the conventional style turbine with change in generator load, some positive means of diverting steam through the extraction opening is essential for operation at light loads. The extraction control for these units is of a positive type which possesses the decided advantage of being able to maintain the desired steam pressure at the extraction outlet irrespective of the electrical load on the unit. This result is accomplished through taking advantage of the double barrel (cross compound) type of unit to insert a control valve on the steam chest of the low pressure barrel. Since the extraction outlet is on the exhaust casing of the high pressure barrel this provides positive means for diverting sufficient steam for heating purposes. The control valve on the steam chest of the low pressure turbine is actuated through a pilot valve and piston to maintain a constant pressure (10 lb gage in this case) at the extraction outlet by restricting the amount of steam which is allowed to pass through the crossover. Sectional views of the high pressure turbine and the control device on the low pressure turbine are shown in Fig. 3. The amount of steam which can be extracted from the house service turbines depends both on the number of units in use and the electrical load being carried on each. Practically the entire throttle flow of the unit can thus be diverted for building heating provided the electrical load on the generator does not exceed the amount of power available from the high pressure turbine barrel. The relation of throttle flow, electrical output, and steam available for heating purposes for a 2150 kw unit of this type is shown in Fig. 4.

A small size reducing station has been provided to step down live steam for summer use to supply the kitchen and domestic hot water supply only, thus making it possible to cut off steam entirely from the building heating system for at least three months of the year and avoid line condensation losses.

Bled Steam Is Hot

As shown by the temperature lines on Fig. 4 the extracted steam, due to its incomplete expansion through the turbine, is still considerably superheated, the total temperature ranging from 315 to 530 F depending on

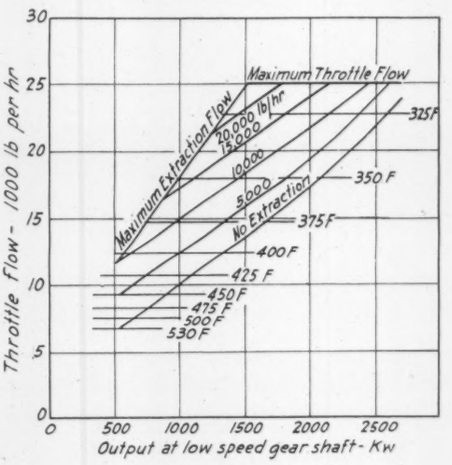


Fig. 4—Relation of throttle steam flow, electrical output, and bled steam available for heating purposes, 2150 kw dc house service unit

generator load. This temperature precludes the use of ordinary soldered parts in radiator and drip traps, unit heater cores and the like, and has even been found destructive to the corrugated bellows of sylphon type packless radiator valves. These limitations have been overcome through the use of high melting point solder or brazing in the manufacture of traps and heater cores, and through the use of more rugged valves having packed stems. With the proper choice of materials no more trouble is experienced with operating at these temperatures than at temperatures in the vicinity of 225 F.

To one not familiar with the use of high temperature bled steam for building heating some trouble might be anticipated on the score of too high a surface temperature on direct radiation being dangerous in the way of burning the unwary who touched against it. Such actually is not the case since the radiation is not appreciably hotter than if it contained saturated steam at 10 lb pressure. The explanation is that since the amount of superheat present represents only about 150 Btu per lb of steam against a latent heat content of around 960 Btu per lb, its ability to overheat a surface where condensation is present is slight. Conditions are different, however, in the case of supply pipes having a steady flow of superheated steam, and these should be insulated where there is a possibility of people coming in contact with them. Trouble on this score can be obviated by placing radiator valves at the lower headers of radiators instead

of at the top headers so that the supply pipe does not extend in an exposed position above the floor.

Vacuum Returns Systems

Due to the large amount of radiation and its scattered location a vacuum returns system aids materially in securing smooth operation. Essex switching station has its own set of vacuum pumps which return condensation at 20 lb gage to a low-pressure stage of the power plant's boiler feed circuit. Returns from other outlying buildings and from the power plant itself are collected into a 6 in. header leading to a set of three vacuum pumps in a pit below the basement floor, Fig. 5. Space is available for the addition of a fourth pump if required later.

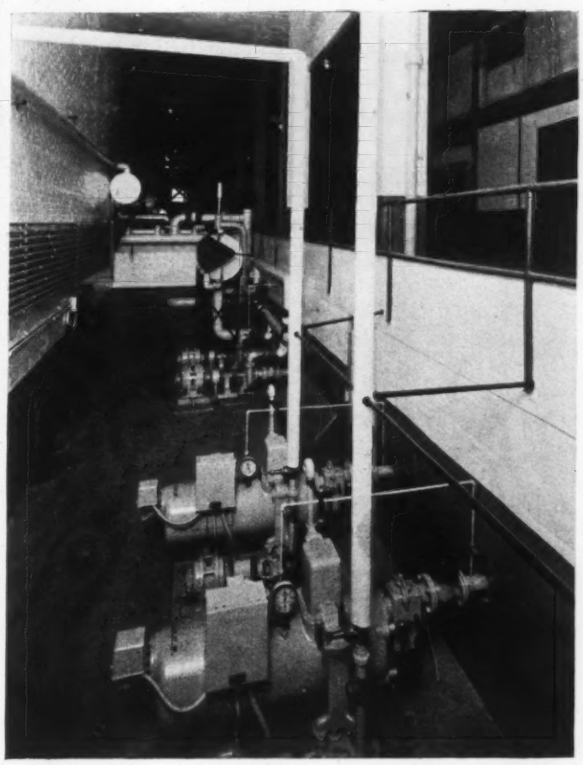


Fig. 5—Heating returns pit, pumps and meters

Return lines leading to this pit pass through pipe tunnels and cable vaults, also below the basement floor and extending to the remote parts of the plant. Pains have been taken to pitch all return lines toward the vacuum pumps and to avoid traps and air pockets with a view to being able in case of failure of these pumps to fall back on a set of booster pumps as explained later, or as a final resort to spill all returns into the sewer by opening a single bypass near the pumps. Due to the fact that the blast heaters are located reasonably close to the pump pit and at sufficient elevation above it, their returns go directly to a gravity receiving tank from whence they are picked up by the condensation booster pumps without going through the vacuum pumps. The flow diagram for the equipment and lines around the heating returns pit is shown in Fig. 6.

Since the supply side of the heating system is operated at all times on a uniform pressure of 8 to 10 lb gage, the returns lines only operate under vacuum and no attempt is made to modulate the steam pressure on the system as a whole to suit the weather.

Temperature Control

Steam supply to the direct radiation is, in general, regulated by hand. In the case of the Essex switching station, however, the direct radiation is divided between five circuits, thus making it feasible to put each circuit under independent thermostatic control to suit the temperature requirements of the portion of the building it serves. Each of these mains has its own motor operated steam supply valve which is controlled by a thermostat placed in a representative location. In the control house there are two circuits, one for the 50 F rooms and one for the switchboard room and wash room which comprise the 70 F region. The main building housing the switch gear is divided into three 50 F circuits, each of which serves its own vertical section of five stories and thus gives flexibility to suit varying exposure. The thermostat for each section is located at a spot selected as representing a reasonably typical exposure for that section. Motor operators for the steam supply valves are geared to open (or close) in times varying from one to three minutes, depending on the size of the valve, in order to minimize any tendency for water hammer. With adequate pitch of the lines to facilitate quick drainage this sort of control has been found to work out well in Essex and in one of the Company's large substations. Where the pitch for drainage is much less than one inch in 20 ft, however, there is apt to be objectionable slamming when the motor operated valves open. Ample capacity drip traps on the mains and adequate pitch have been found essential to the quiet operation of such systems.

While thermostatic control of unit heaters is used in a few isolated shops around the power plant, those heaters which are located in more or less open spaces are equipped with motors having three speeds which are set by hand. In the case of the blast heaters, a dc motor with a multispeed control is used to drive the fan, and two out of four banks of heaters are fitted with thermostatic control, the other banks being turned on or off manually as required.

On the whole the mixture of manual and thermostatic control outlined above has worked out very well for several reasons: (a) steam is relatively inexpensive in a power plant compared with the cost of full thermostatic control; (b) heat is required continually in most parts of the plant, 24 hours a day seven days a week from fall till spring, thus rendering night or week-end shut-off unnecessary; (c) in the present combination of automatic with manual control, the base load can be taken pretty much by the latter while the former is used to compensate for changes in outdoor temperature.

Metered Returns: All heating condensation is metered before being returned to the power plant feed water system. Metering is desirable both from a standpoint of the power plant heat balance and as a check for design purposes. Essex switching station has its own condensation meters on the suction side of its duplex vacuum pumps. Condensation from the blast heaters flows by gravity through a meter on its way to the receiver of the condensate booster pumps. Due to the low level at which the returns lines must approach the vacuum pumps

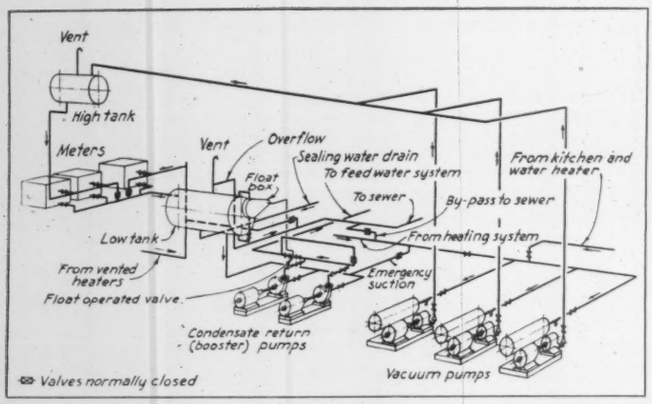


Fig. 6—Flow diagram of equipment in heating returns pit

for the main plant there was insufficient elevation to put meters on the suction side of these pumps. This, coupled with the fact that the 10 lb discharge head of the existing pumps was hardly enough for them to return water directly to the power plant feed circuit, dictated the use of booster pumps and placing the meters between the two sets of pumps as shown diagrammatically in Fig. 6.

Booster Pumps: The booster pumps serve a double purpose in that they also pump back a considerable amount of distilled water overflowing from shaft packings and water sealed valves around the power plant which is not metered. These booster pumps, which are capable of handling up to 250 gpm each at a discharge head of 25 lb gage, take their suction from a receiving tank vented to the atmosphere. The pumps run at constant speed with a float actuated throttling valve in their discharge to prevent pumping the receiving tank dry. Except in extremely cold weather either booster pump can carry the entire plant, thus leaving one pump in reserve. If future expansion of the power plant should tend to overload these pumps with sealing water, space is provided for the installation of a third pump. Due to the mixing of relatively cool water from pump and valve seals with the heating returns the temperature in the receiving tank is kept down to about 160 F, which fact coupled with a small positive elevation head permits the use of ordinary centrifugal pumps for boosters without danger of cavitation. In an emergency these pumps can draw water directly from the heating returns header without having the vacuum pumps in operation, under which conditions the returns header would be vented to atmosphere through the receiving tank just ahead of the booster pumps.

Old Equipment Salvaged

In revamping the existing heating system in conformity with modern practice the old equipment has been reused in so far as practicable. The old vacuum pumps and booster pumps have been thoroughly overhauled and moved from a rather inaccessible location below the basement floor to an open pit where they are fully as accessible as similar auxiliary equipment around the power plant. A new 14 in. steam header has been installed, mainly out of pipe and fittings salvaged from the old power piping, for the purpose of collecting and distributing bled steam throughout the plant. The pressure reducing valves from two isolated stations have been reused in a single station to provide an emergency steam supply connected into the new header at one point. Existing supply and return branch lines have been re-used for connection to the new headers by the most direct available routes, and the lines to the kitchen equipment and domestic water heaters have been enlarged and rearranged, and their returns individually trapped so as to operate on 8 to 10 lb bled steam during the heating season instead of having to use 30 lb live steam all year 'round. At the same time the heating system has been extended to serve an addition to the turbine room which will house two new 60,000 kw turbo-generators. Through these measures the existing heating system, much of which is fifteen to twenty years old, has been adapted to new conditions and put in good shape at a relatively small cost.

Constanta, Rumania, on the Black Sea, an important oil port, showing the oil pipe lines

Forced Circulation Hot Water System Heats Plant in Change-Over from Steam

By **Samuel R. Lewis***

SOME months ago, one of the editors of HEATING, PIPING, AND AIR CONDITIONING phoned me as follows: "I have a letter from one of our readers, a plant engineer, who says that in the large factory which he supervises there is difficulty with corrosion from the inside of the steam and return piping. The plant is only about six years old, he says, and the management has had exhaustive studies made by chemists and other experts without having arrived at a solution. They wonder whether we can do anything to help them. I've made a date to call at the plant. Would you like to accompany me?"

We found a beautiful and modern five story manufacturing plant heated almost exclusively by steam unit heaters. The basement space is a warehouse for storing the concentrated raw material and the first four stories are merely conveyor-fed reservoirs which fill up and empty themselves like water behind a dam, so as to iron out the differences between the rate of production from the automatic machinery on the fifth floor and the ebb and flow of freight train shipments. It is heated by 67 large capacity recirculating unit heating machines placed overhead and usually near the outside walls each controlled by an electric thermostat in the zone of influence of its particular heater.

Steam at 100 lb pressure entered the building from a nearby boiler plant at the fourth story level and was distributed through a supply main near the fourth story ceiling, feeding up to the fifth story heaters and down to those on the lower floors. The steam risers were paralleled with return mains which drained to a main near the basement ceiling. This main ran to the receiver of a centrifugal pump which forced the condensation up to the fourth story ceiling and back to the boiler house. The steam is purchased on the basis of flow meter records and was reduced to about 50 lb pressure, the steam thus being superheated to the temperature of 100 lb pressure, which is around 337 F.

The original design of the plant contemplated that steam at 50 lb pressure (about 296 F) should be used in the unit heaters and in the 61 miter type pipe coil radiators in the offices, stair halls, toilets, etc. as the designer apparently felt that cast iron radiators would not withstand the pressure. No provision was made for extracting the sensible heat remaining in the condensate. For service hot water, required in considerable amounts, steam was used directly at 50 lb pressure in a manifold in the water tank.

No one seems able to explain just why such a high pressure was employed, or why, when the steam was purchased on a steam flow basis, the sensible heat in the return water should be sent back as a free gift to the corporation which furnishes the steam.

The original heating installation was equipped with thermostatic vacuum traps at the bottoms of the downfeed risers, at each unit heating machine and at each radiator, some 150 of them. There was no vacuum pump and the condensation receiver had an inadequate vent. This small atmospheric vent was occupied fully in ejecting to waste the steam which flashed from the condensate when the traps passed the superheated water into the return mains.

The traps failed and were replaced, but the replacements quickly failed. Float traps were installed. However a leak appeared in a steam riser after a short time wetting down and ruining some hundreds of dollars in value of raw material. "Just an accident," they thought, and replaced the guilty piece of piping. Shortly, other leaks appeared and kept appearing until it was realized that damage amounting to thousands of dollars might easily be encountered unless some radical cure for the trouble could be discovered.

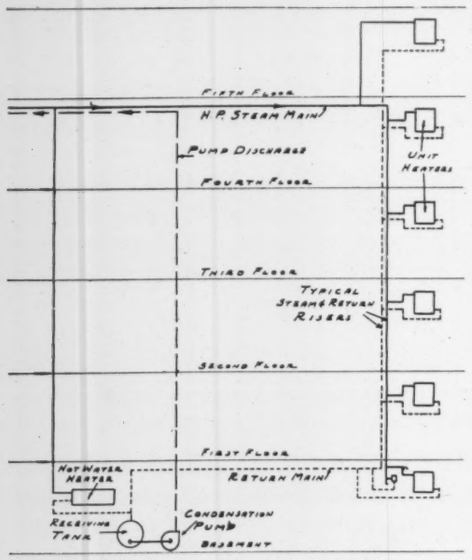
The condensate from the steam was analyzed; by the time the sample could be studied it showed no untoward reaction. The samples of liquid, of course, by the time they could be analyzed, were exposed to the air and were cool. There was no way to analyze the fluid in the form of steam or hot water in the presence of the high temperature and in the presence of whatever mysterious gas might be at work inside the pipes while in service.

The metal of the piping was subjected to test and was found to be all that any one could ask. Still the interior of the piping was being eaten up as if by some concentrated acid. Leaks came in steam as well as in return lines; they appeared in the centers of pipes far from threads and they came at threads; they appeared in risers as well as in horizontal pipes. The possibilities of electrolysis from stray electric currents were exhausted without improvement. Joints in pipe coil radiators as well as in the mains would break loose without warning.

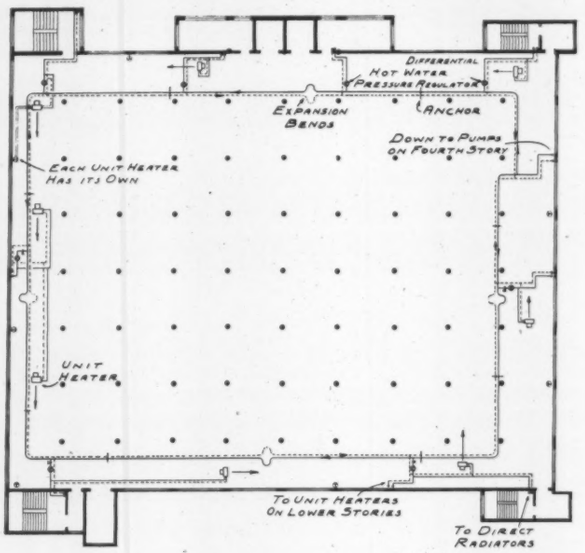
This was the situation on the day that we visited the plant.

I asked, "Where is your air vent?" The answer was, "Why, the air escapes through the atmospheric relief pipe from the condensation receiver." I asked, "Have you had any trouble with the continuous copper coils of the unit heaters?" The reply was "No." I asked, "Have you no air vents or air relief valves on the convectors of the unit heaters or on the pipe coils?" The answer was "No." I asked, "Have you had any trouble with heating?" They replied that there were unexplainable vagaries with the heating; that some units could be depended upon to give an ample and reliable supply of warm air, while others sometimes failed to heat properly.

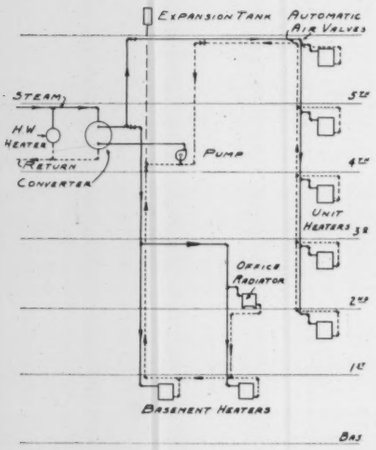
*Consulting Engineer, Chicago, Ill. Member of Board of Consulting and Contributing Editors.



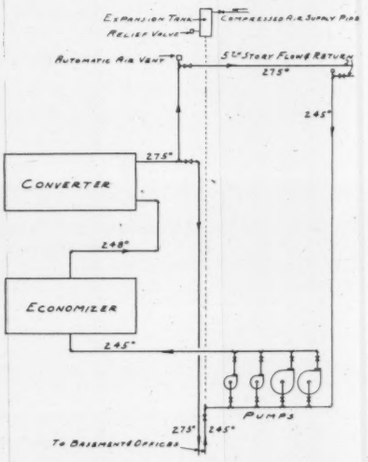
Original scheme of steam circulation with supply main near fourth story ceiling



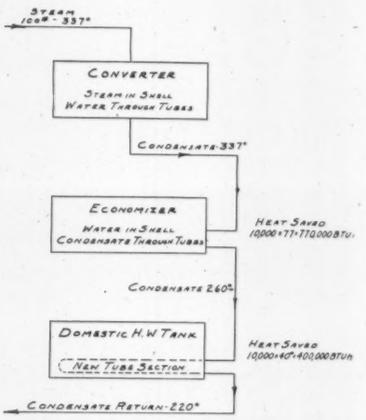
Plan of fifth story showing revised supply and return mains, with typical location of unit heating machines



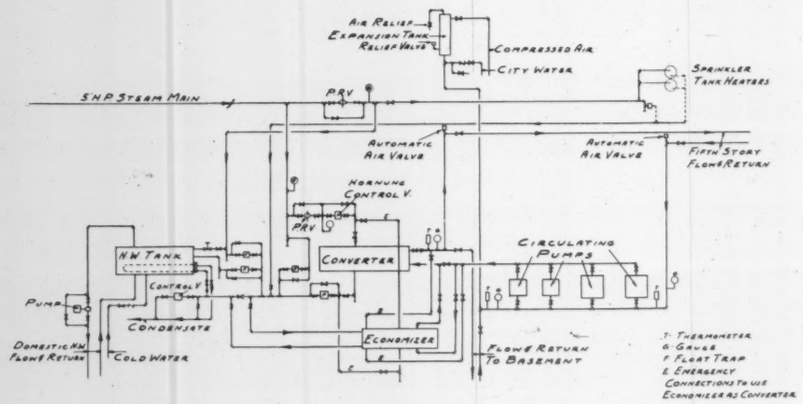
Arrangement for water circulation, with heaters at the fourth story and mains near the fifth story ceiling



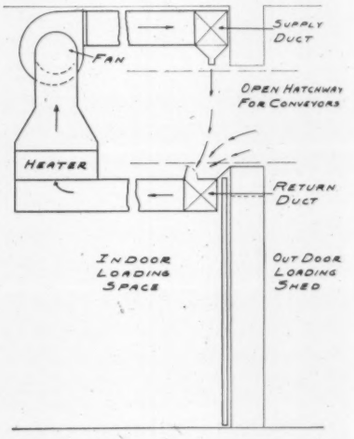
Water flow diagram for new system, showing the design temperature



Steam and condensation flow diagram for the new system showing the design temperatures. The heat savings noted are for maximum load beyond those formerly possible



Valves and piping at the heat transfer station on the fourth story



An invisible barrier of warm air across the conveyor hatchway prevents undue entry of cold air

The gage glass at the condensation pump which should normally have indicated a clear liquid showed something that looked like red barn paint. My diagnosis of course was that the unusually rapid oxidization of the interior of the ferrous piping was due to excess air in the presence of high temperature and moisture.

Had the mains and the unit heating machines been designed originally for low pressure, it might have been practicable to change to a vacuum system of steam circulation by installing a proper air and water suction device. However, this would have required rebuilding the mains and risers in much larger diameters and adding many new unit heating machines.

It developed that the basement storage space with its raw material, especially susceptible to any moisture, must be heated even in summer to prevent any deposition of dew when the outside air turned warm suddenly following some days of cool summer weather, and that the owner wished especially to minimize all piping carrying liquid or steam in the basement for fear of more leaks with their attendant potential damage.

Because of unusual difficulties with corrosion of steam and return piping, complicated by the possibility of damage to stored raw material and the fact that steam was bought from an adjoining plant and its generation was therefore not under control of the purchaser, a large manufacturing plant decided upon a change-over to forced hot water heating, the circulating water to be heated by the purchased steam.....The author, who recommended this solution and served as the consulting engineer, describes how the job was done

The original heating arrangements did not provide any separate basement heating system and of course required rather extensive return mains in the basement to drain the various down-coming risers from the upper stories as well as to drain the basement heating apparatus.

I recommended that the plant be changed to use forced circulation hot water at the same pressure in cold weather as the former steam, thus giving the same heat output as would the steam, the water at this high temperature being prevented from boiling by an artificially maintained pressure. Thus all air would be excluded from the piping and any mysterious corrosive gas would be replaced by a neutral liquid which would remain in the plant and never go back to the boilers where any chemical treatment or lack of chemical treatment would be beyond our control. This solution was finally decided upon, and I was asked to serve as consulting engineer.

The change-over presented several interesting problems. If one is heating a five story building with steam or hot water and if the supply main is at the fourth story ceiling, the design of branches and risers and drainage and air venting is peculiar and decidedly complicated in comparison to a design which has the supply and return mains in the basement or which has the supply main at the top of the system.

Piping Is Copper with Sweated Fittings

It was decided to use copper for the mains and branches to eliminate any possible electro-chemical action between the copper tubing of the unit heaters and the piping supplying the units. Accordingly the new system is iron pipe size hard copper with brass fittings and the supply and return mains are on the fifth story instead of being on the fourth story so that air venting is out of the top of the system.

The separate mains for heating the raw material stock room in the basement are located insofar as practicable on the first story. Instead of the original 6 in. steam supply main the new forced water supply main is 5 in. and is paralleled with a similar 5 in. return main. In making up the sweated joints employed, two men sawed the tubing into the proper lengths, cleaned and smoothed the ends and slipped them into the various hangers and fittings. Two other men followed with the oxy-acetylene torch and simply warmed up the fittings evenly until the silver-like melted composition, which had been factory applied to each fitting, appeared between the pipe and the fitting. In the case of the very few leaks which appeared upon testing, the joint easily was reheated so that the solder could flow into the void, An adjustable man-carrying four-wheel truck-scaffold was employed for hoisting the lengths of piping and the workmen. It was adjustable both vertically and laterally, even under heavy load, and its use speeded up the progress of the work very materially.

There are no slip expansion joints, but loops and spring pieces at the centers of each of the four straight runs at the sides of the building, aided by free movement at the corners, care for expansion, with anchors placed in intermediate positions.

Control and Balancing of System

There is an automatic pressure differential valve for each general division of the system, the valve being in the supply main and responding to the pressure in the corresponding return main so that regardless of the initial pressure and temperature, only enough water is admitted to maintain a constant differential pressure in the return. Thus if the group of units or radiators served by that particular branch or riser requires 3 lb friction loss, the valve will admit enough water and no more, so that this loss is balanced. Over-pumpage of water and inefficiency are thus prevented, and the parts of the system which are most remote or which require the most heat, are fed adequately and cannot be starved by short circuiting of water through some easier bypass.

Each general division of the system has lock shield gate valves and each heat transmitting unit has tight valves on both flow and return to facilitate repairs or changes. The exact temperature drop of the water re-

quired through each unit, about 25 F for a normal balancing, is ascertained and adjusted by manipulating and setting permanently the valves at the units.

To accomplish this adjustment a thermocouple was employed, which indicates instantly the temperature of the inlet pipe and of the outlet pipe. Very little adjustment of the individual valves was required, the automatic pressure differential main line valves apparently correcting such mistakes in the design as might have occurred. By employing water at variable temperature in the radiators of the offices great improvement in comfort is achieved.

Heating the Circulating Water

The circulating water is heated by steam from the old main at the fourth story and the steam pressure is reduced and varied to facilitate the operation of the automatic water temperature regulator. The steam flows around a nest of U-shaped copper tubes within an insulated cast iron tank. The water circulates through the tubes and an aquastat in the leaving water controls in stages the admission of steam. If the steam pressure is reduced in accordance with the weather nearly all of its superheat and the latent heat of condensation is transferred to the water and the control valve does not hunt. The condensation from the main heater passes to an economizer heater, where it transfers heat to the returning relatively cool water of the heating system. This water using transfer heater is cross-connected so that in any emergency it may be supplied with steam in parallel with or as a spare for the first heater. The condensation next passes to a manifold in the service hot water heater, which was moved from the basement to the fourth story and which now has its own small water circulating pump, and normally heats all of this water before departing by gravity to the boiler plant. Under the old scheme it was necessary to pump this condensation up four stories from the basement return main. The condensation ordinarily can be cooled down to around 140 F, a very substantial saving compared to the 280 F or so at which it formerly was allowed to depart. It would be possible further to extract the heat from the condensation by sending the warm water through one of the unit heaters on the fourth story, but since the amount of condensation varies widely with the weather we have not yet undertaken this ultimate economy.

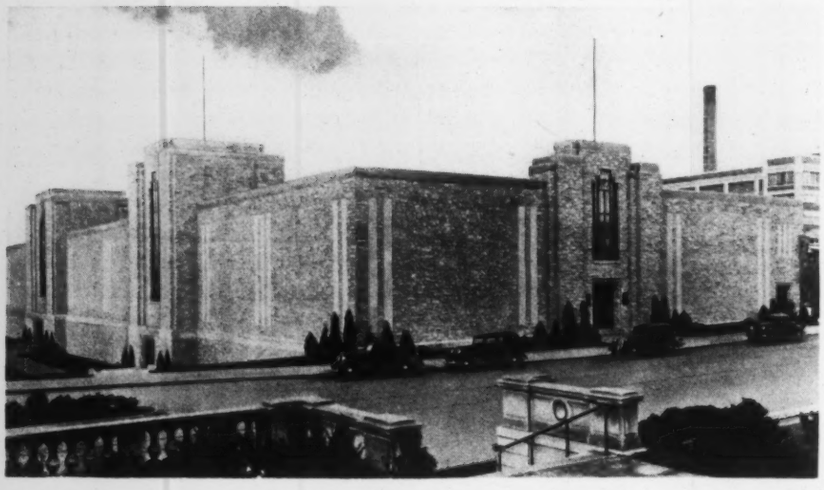
The old duplicate centrifugal condensation pumps were re-used as circulating pumps, one always being in reserve, for the separate basement heating system. New circulating pumps, in duplicate, were purchased for the balance of the building; they are unusual in that they are driven by separate motors through multiple V belts. The expansion tank was placed above the fifth story level in an existing pent house, so that practically all air from the system vents to it. It has sufficient capacity so that expansion of the water in the system varies the level within the tank within easy range of observation in the length of the sight glass, and there is a relief valve and a small air compressor so that the boiling temperature of the water may be adjusted easily by pressure variation to suit the demand on any day.

Open Hatchway Blanketed with Warm Air

The plant includes a large shipping department with arrangements for delivery of the product by automatic conveyors directly to railway cars. These conveyors pass through an open hatchway in an outside wall of the building, and the cold air entering through this hatchway, which is about 8 ft long and 3 ft high, has always been troublesome. A special unit heating machine had been used to deliver warm air toward the hatch, but since the air supply to replace any warm air which escaped through the top of the hatch must come from outside, cold air entered through the bottom of the hatch and proved very objectionable.

This problem was solved reasonably well by installing a centrifugal blower handling 4,000 cfm of air, delivering it at right angles across the narrow way of the hatchway at high velocity and collecting it through a similar slot, returning it for recirculation. This scheme of creating an invisible barrier of warm air without encouraging either outward or inward flow through the hatch seems to operate very satisfactorily, particularly as it tends to pick up such cold air as enters and to prevent this air from falling to the floor.

I have been modest about writing this story until a cold weather test was actually encountered. The temperature finally did hit zero. On that morning the plant reports comfort; hence, the story appears.



Thirteen thousand, eight hundred and sixty people — five times the population of Hershey, Pa.—visited the new, air conditioned, windowless office building of the Hershey Chocolate Corp. on December 28, the opening day. Numerous features have been incorporated in the design of the structure, and two separate air conditioning systems—one for the general offices and the other for the printing department and paper storage rooms—maintain proper indoor conditions based on outdoor temperatures to avoid shock on entering or leaving. The air conditioning systems will be described in an early issue

SHOW SECTION

Meeting Programs

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List of Exhibitors

At the Palmer House Hotel —the annual meeting of the American Society of Heating and Ventilating Engineers

At the International Amphitheater—the Fourth International Heating and Ventilating Exposition

Exposition Highlights

•

Social Activities

•

Map and Diagram

At the Stevens Hotel—the annual convention of the National Warm Air Heating and Air Conditioning Association

1936			JANUARY			1936
SUN	MON	TUE	WED	THU	FRI	SAT
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

"The Big Week" for the air conditioning, ventilating and heating industry, January 27-31 at Chicago. Complete information is given in this special show section

January, 1936
Chicago, Ill.

Chicago from Lake Michigan

JANUARY 27 to 31—

THE INDUSTRY IS ON DISPLAY—IN CONFERENCE—AT CHICAGO

OPPORTUNITY to explore, discuss and experience what is happening in equipment development, engineering research and practice in air conditioning, heating and ventilating is provided in unstinted measure in Chicago during the week of January 27.

At the International Amphitheater close to three hundred manufacturers are displaying their products in the 4th International Heating and Ventilating Exposition, more familiarly known this year as "The Air Conditioning Exposition." This is the most complete showing in the industry's history of equipment used in air conditioning, heating and ventilating for everything from the home to the large building and industrial plant.

At the Palmer House the *American Society of Heating and Ventilating Engineers* is holding its 42nd annual meeting. The technical papers to be presented at its sessions on research developments and engineering problems involved in air conditioning, heating and ventilating are of outstanding educational and practical value.

At the Stevens Hotel the *National Warm Air Heating and Air Conditioning Association* is holding its 23rd annual convention. Its program of papers and discussions deals with important warm air heating and residential air conditioning subjects.

The "Show"

The Exposition is sponsored by the *American Society of Heating and Ventilating Engineers* and will be formally opened by John Howatt, president of the Society, in the presence of Society officers and council members at 2:00 p. m. on Monday, the 27th. Through Friday, the 31st, it runs from noon until 10:30 p. m. each day. The International Amphitheater, located at 42nd and Halsted streets, Chicago, is a new building, beautifully adapted to exhibit purposes. In the last few months such important shows as the National Metals Exposition, the Automobile Show and the Live Stock Exposition have been held there, with outstanding attendance records and excellent display facilities fully justifying its selection for The Air Conditioning Exposition.

It is easily reached by bus, street car, elevated and taxi from Chicago's Loop and has that rare convenience feature seldom found in large cities—free parking space right at the door capable of accommodating 6,000 cars. The map on another page shows the locations of the Amphitheater and the two hotels, as well as the most direct transportation routes.

The exhibits have been carefully planned by manufacturers. Electrical, steam, water and compressed air services which are available have been utilized to show equipment in actual operation. Many new products are being unveiled for the first time. Unusually striking methods of display are being employed to add beauty and interest to the practical value of the showings. Officials and representatives of each concern are in attendance at the booths to answer all questions. A detailed listing of the exhibitors and what they are exhibiting appears elsewhere in this section.

THE WEEK AT A GLANCE

EVENTS: **4th International Heating, Ventilating and Air Conditioning Exposition.**
42nd Annual Meeting American Society of Heating and Ventilating Engineers.
23rd Annual Convention National Warm Air Heating and Air Conditioning Association.

PLACE: **Chicago.**
Exposition—International Amphitheater, 42nd and Halsted Streets.
A.S.H.V.E.—Palmer House.
N.W.A.H.A.C. Assn.—Stevens Hotel.

TIME: **Exposition—Opens 2:00 p. m., Monday, January 27, and 12 Noon other days. Closes 10:30 p. m. each evening, January 27-31.**
A.S.H.V.E.—Technical Sessions Tuesday, Wednesday and Thursday mornings, 9:30 to 12:30. Joint session Wednesday afternoon with N.W.A.H.A.C. Association.
N.W.A.H.A.C. Assn.—Technical sessions Wednesday and Thursday mornings.
Joint session with A.S.H.V.E. Wednesday afternoon.

TIP: **When in doubt go to "Illinois Chapter Convention Room" at Palmer House—information and social center.**

The International Amphitheater

The Meetings

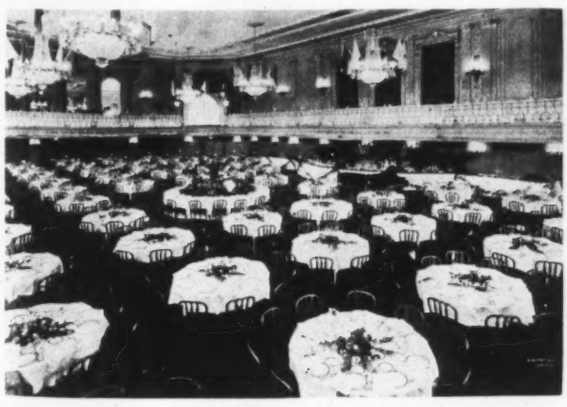
After registration on Monday the program of the *American Society of Heating and Ventilating Engineers* at the Palmer House calls for technical sessions on Tuesday, Wednesday and Thursday mornings, with Wednesday afternoon devoted to a joint session with the *National Warm Air Heating and Air Conditioning Association* at the Stevens. The latter organization holds its technical sessions on Wednesday and Thursday mornings.

The papers to be presented and discussed are listed on another page. They have been carefully selected to cover subjects of vital importance to current and future practice and the man who would keep abreast of his field will make it a point to be at the Palmer House or Stevens when those of particular interest to him are on the program.

From an educational and informative standpoint this combination of Exposition and meetings well deserves the description of "The Industry's Big Week." Seldom, if ever, in the industry's history has anything equal in scope or significance been presented in so complete and convenient a fashion. In a few days, all in the one city, are educational opportunities far more than the equivalent of months of study and travel.

Recreation

On the lighter side, recreation and opportunities for contacts and sociability have been just as carefully arranged. The Illinois Chapter of the *American Society of Heating and Ventilating Engineers* is official convention host and, mindful of the fact that Chicago's own John Howatt is president of the Society, has spared no efforts to make the week a memorable one in hospitality and entertainment. General Chairman of Arrangements is J. H. Milliken, who, with Vice Chairman J. J. Hayes, has effected a committee organization of Chicago members to handle the reception, entertainment and other interests of visitors. J. R. Vernon heads reception activities; Tom Brown is in charge of entertainment; Carl F. Hayden is responsible for the ladies; J. P. Fleming is running the annual banquet; Byron L. Casey arranges transportation; Elmer W. Rietz handles the finances; and C. E. Price is in charge of publicity.



Palmer House Ballroom ready for the Banquet

An informal reception at the Palmer House Monday night . . . a get-acquainted luncheon on Tuesday . . . a house-warming party Tuesday evening with dance music and entertainment . . . the annual banquet on Wednesday night, with dinner music, favors for the ladies, speakers and dancing later . . . are features of the program. At the banquet arrangements have been made for a broadcast by John Howatt on the Armco program which is dedicated that night to the air conditioning industry. The presentation of the F. Paul Anderson Medal and the Past President's Emblem also takes place at the banquet. Toastmaster is Oliver J. Prentice and speaker of the evening is Major John L. Griffith, the title of whose address is "Competition in Athletics and in Business."

An "Illinois Chapter Convention Room" for members, ladies and guests of the Society will be open throughout the convention at the Palmer House to provide constant opportunity for contacts and sociability with all those in attendance, as well as to be general information headquarters. It is in this room that the Monday night reception and the Tuesday night party are to be held, and it is to this room that every one should repair when the question is "What next to do?"

The ladies will find their interests taken care of with plans for shopping, sight-seeing, bridge and other diversions to fill their time while not attending such functions as those above. The starting point for all such affairs is the Illinois Chapter Convention Room.

It all adds up to a big week. The purpose of this special "Show" Section is to present the details for the guidance of those who wish to make the most of it.

PROGRAMS

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

42nd Annual Meeting

Palmer House — January 27-30, 1936 — Chicago, Ill.

January 27 (Monday)

9:30 a. m. Registration—Ball Room Foyer.

10:00 a. m. Business Meeting (Red Lacquer Room).
Greetings—President John Howatt.
Reports of Officers.
Reports of Council Committees.
Reports of Special Committees:
Committee on Research, Prof. A. P. Kratz, Chairman.
Guide Publication Committee, Prof. G. L. Larson, Chairman.
Committee on Ventilation Standards, W. H. Driscoll, Chairman.
Committee on Constitution and By-Laws, W. T. Jones, Chairman.
Report of Tellers of Election.

2:00 p. m. Opening of the Fourth International Heating and Ventilating Exposition—International Amphitheater, 42nd and Halsted Streets.

3:00 p. m. Meeting of the Council.

8:30 p. m. Informal Reception—Illinois Chapter Convention Room, Palmer House.

January 28 (Tuesday)

8:30 a. m. Registration—Ball Room Foyer.

9:30 a. m. Technical Session—Red Lacquer Room.
Call to Order, by President John Howatt.
Welcome to Chicago—Hon. Edw. J. Kelly, Mayor of Chicago.
Thermal Properties of Concrete Construction—F. B. Rowley A. B. Algren and Clifford Carlson.
Comparative Study of Combustion Results with Various Thermostats—B. E. Shaw.
Fuel Saving Resulting from the Use of Storm Windows and Doors—A. P. Kratz and S. Konzo.

12:30 p. m. Get-Acquainted Luncheon (Members, Guests and Ladies).

2:30 p. m. Meeting of Committee on Research.

2:30 p. m. Meeting of Chapter Officers.

4:00 p. m. Organization meeting of Nominating Committee.

10:00 p. m. to 1:00 a. m. House Warming Party.

January 29 (Wednesday)

9:30 a. m. Technical Session—Red Lacquer Room.
Performance of Fin-Tube Units for Air Heating, Cooling and Dehumidifying—G. L. Tuve.
Subjective Reactions of Human Beings to Certain Outdoor Atmospheric Conditions—C.-E. A. Winslow and L. P. Herrington.
Ventilation Requirements—C. P. Yaglou, E. C. Riley and D. I. Coggins.
Airfoil Fan Characteristics—W. A. Rowe.

2:00 p. m. Warm Air Heating & Cooling Session with *National Warm Air Heating and Air Conditioning Association* at Stevens Hotel.
Room Surface Temperature of Glass in Windows—J. E. Emswiler and W. C. Randall.

7:00 p. m. Annual Banquet and Dance—O. J. Prentice, Toastmaster; Maj. John L. Griffith, Speaker; Presentation of F. Paul Anderson Medal and Past President's Emblem.

January 30 (Thursday)

9:30 a. m. Technical Session—Red Lacquer Room.
Comfort Standards for Summer Air Conditioning—F. C. Houghten and Carl Gutberlet.
Corrosion Studies in Steam Heating Systems—R. R. Seeber, F. A. Rohrman and G. E. Smedberg.
Unfinished Business.
Installation of Officers.
New Business.
Resolutions.
Adjournment.

12:30 p. m. Luncheon and Meeting of the Council.

2:30 p. m. Meeting of Guide Publication Committee.

NATIONAL WARM AIR HEATING AND AIR CONDITIONING ASSOCIATION

23rd Annual Convention, Stevens Hotel, January 29-30, 1936, Chicago, Ill.

January 29 (Wednesday)

President H. T. RICHARDSON, *Chairman*

8:30 a. m. Registration.

10:00 a. m. Call to Order and Announcements.
President's Message, H. T. Richardson, New York.

10:30 a. m. Federal Housing Administration—Recent Developments and Progress Made—A. O. Eberhart, Federal Housing Administration.

11:00 a. m. Insulation, Why and How—J. D. Hoffman, Purdue University.

11:30 a. m. The Application of Gas to Warm Air Heating Systems—H. B. Johns, Peoples Gas Light and Coke Company, Chicago.

12:00 Noon Recess.

2:00 p. m. Joint Meeting of the *American Society of Heating and Ventilating Engineers*, and *National Warm Air Heating and Air Conditioning Association*.
Chairmen—John Howatt, President A.S.H.V.E.; H. T. Richardson, President N.W.A.H.&A.C. Association.
Room Surface Temperature of Glass in Windows—J. E. Emswiler and W. C. Randall, A.S.H.V.E.
Outline of the A.S.H.V.E. Research—A. P. Kratz, Committee Chairman.
Research Advisory Committee Report, N.W.A.H. &A.C. Association—F. G. Sedgwick, Chairman, Minneapolis.
Progress Report on Residence Cooling Using Water from City Service Mains—S. Konzo, Special Research Associate, University of Illinois.

5:00 p. m. Recess.

7:00 p. m. *American Society of Heating and Ventilating Engineers* Banquet, Red Lacquer Room—Palmer House.

January 30 (Thursday)

Vice-President W. L. RYBOLT, *Chairman*

9:30 a. m. Installation Codes Committee Report—J. D. Hoffman, Chairman.

10:00 a. m. Merchandising in Our Industry—L. R. Taylor, Utica, N. Y.

10:30 a. m. The Combination Furnace Heating and Cooling Plant—Platte Overton, Chicago.

11:00 a. m. The Bituminous Coal Industry's Program of Research in Domestic Heating—Ralph A. Sherman, Battelle Memorial Institute, Columbus, O.

11:30 a. m. Report of Board of Directors and Committees.

11:50 a. m. New and Unfinished Business—Open Forum.

12:15 Noon. Election of Officers.

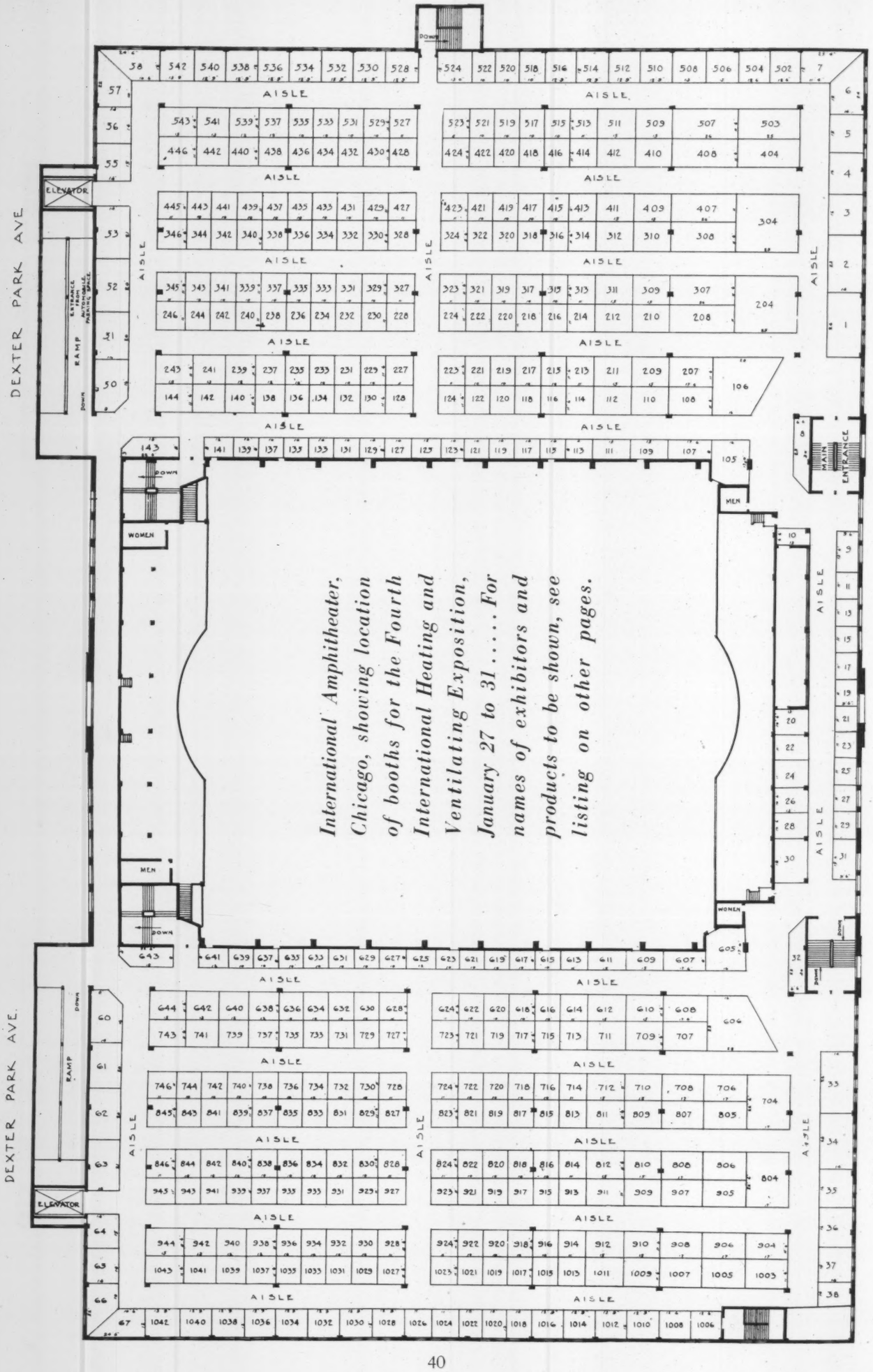
12:30 p. m. Final Adjournment.

List of Exposition Exhibitors and Their Exhibits

On these pages will be found the names of manufacturers who are exhibiting at the Exposition, their booth numbers, the names of representatives who are in attendance and a condensed list of the products being exhibited. Those who desire to locate any manufacturer's booth will find the exhibitor's name listed in its proper alphabetical place and opposite it his booth number. The diagram of the exhibit hall is on another page showing, by number, the location of each booth. Any additional information will be gladly supplied by HEATING, PIPING AND AIR CONDITIONING at Booths 322-324.

Available advance information on new products being shown for the first time at this show is given herewith, as well as information on operating exhibits, for the benefit of those who are particularly interested in the latest developments and in construction and operating details. Improved, modern design, however, is the feature of every exhibit and inspection of every booth is recommended.

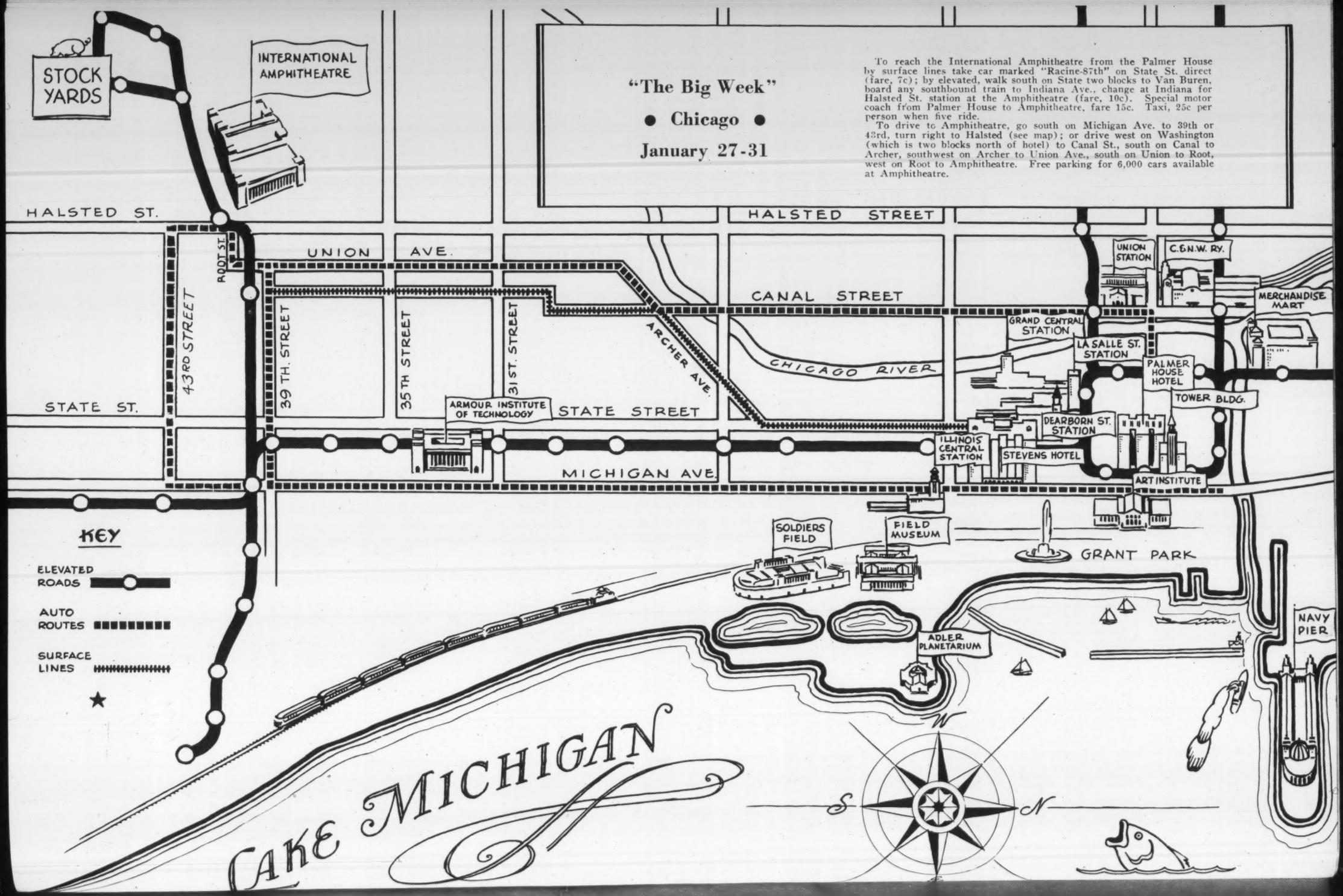
Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
A. C. E., Inc., Chicago, Ill	235		Instruments
Ace Engineering Co., Chicago, Ill	738		
Adams Engineering Co., Chicago, Ill	716	B. E. Adams, J. R. Hilton, P. A. Frank, J. Ingrisch	Water heaters
Aerofin Corp., Newark, N. J	338	John F. Hale, H. D. Jackes, L. C. Soule, Milner Noble	Fan system heating and cooling surface
Aerologist, The, Chicago, Ill	235		Publication
Air Controls, Inc., Cleveland, Ohio	19–21	W. E. Van Horne, B. G. Krause, H. Howell, O. A. Harris, J. P. Kraft	Blower—filter units for forced air heating and air conditioning; air circulators; blowers for air conditioning
Airtherm Mfg. Co., St. Louis, Mo	11	A. L. Byfield, Harry Himelblau	Unit heaters
Alco Valve Co., Inc., St. Louis, Mo	11	J. A. Schenk	Automatic refrigeration control valves for air conditioning and product cooling
Allis-Chalmers Mfg. Co., Milwaukee, Wis	219–221–223	B. F. Bilsland and staff	Motors, centrifugal pumps, rotary air compressors, V-belt drives, including the new vari-pitch sheave.
American Artisan, Chicago, Ill	322-324	Keeney Publishing Co	Publication
American Blower Corp., Detroit, Mich	508	R. S. Southmayd	Air conditioners, unit heaters, furnace fans
American Brass Co., New York, N. Y	421–423	W. Harold Dowd	Deoxidized copper tubes with cast bronze and wrought bronze fittings; Everdur in the form of all welded tanks, castings, ventilators, ducts and electrical conduit; copper sheets for weather-proofing and dampproofing
American Gas Accumulator Co., Newark, N. J.	138		
American Gas Association, New York, N. Y.	50–51		
American Gas Products Corp., New York, N. Y.	506	H. H. Dugdale, A. I. Wallace, T. E. Grant	Gas-fired boilers; water heaters.
American Radiator Co., New York, N. Y	6–7 & 500	Arthur R. Herske, W. Walter Timmis, Kimball Burr, W. H. Walker, J. H. Roberts, L. M. Butler, G. R. Atherton, R. F. L'Hote	Oil burning boiler; boiler for automatic coal firing; boiler with year-round hot water supply hook-up; radiators and convectors; air conditioner; heating accessories; copper pipe and fittings; cast iron pipe; air filters
American Rolling Mill Co., Middletown, O	238–240	T. I. Byrd, G. F. Ahlbrandt, R. A. Dadisman, D. C. O'Brien	Galvanized duct work showing difficult formations and construction details; world's largest stainless steel polished sheet; photo—enlargements of typical duct installations; samples of sheet grades and finishes adaptable to the air conditioning industry
American Sheet & Tin Plate Co., Pittsburgh, Pa.	52–53		Sheets
American Society of Heating & Ventilating Engineers, New York, N. Y	8–10–20	F. C. Houghten and Society Staff.	First public appearance of 1936 Guide; tickets on sale for social functions of conventions; research material
American Steam Pump Co., Battle Creek, Mich.	706	W. P. Whittington, Gordon B. Fisher, Geo. A. Willis, Anthony C. Florek	Duplex vacuum heating pump
American Steel & Wire Co., New York, N. Y.	52–53		Wire products
American Thermometer Co., St. Louis, Mo	710		Thermometers
Anderson Mfg. Co., Cambridge, Mass	611	L. L. Lasher, Oscar Andersen, J. E. Stacey	Air valves for direct and convector type radiators
Armstrong Bros. Tool Co., Chicago, Ill	129	William T. Armstrong, Horace Armstrong, J. O. Armstrong, L. F. Armstrong, Jas. A. Freeman.	Steamfitters' and plumbers' tools
Armstrong Cork Products Co., Lancaster, Pa.	246	H. J. Krampe, C. W. Robinson, C. E. Gibson	Corkboard and cork covering; vibracork; temlok; insulating brick
Armstrong Mach. Wks., Three Rivers, Mich.	115	A. E. Armstrong, T. H. Rea, O. E. Ulrich	Steam traps
Automatic Burner Corp., Chicago, Ill	512–514	J. H. Hirsch, E. J. Reller, Joseph Hirsch, E. A. Weil, W. J. Sarrasin	Oil burners; boiler-burner unit; heaters; range burners; matched basement unit.



International Amphitheater, Chicago, showing location of booths for the Fourth International Heating and Ventilating Exposition, January 27 to 31..... For names of exhibitors and products to be shown, see listing on other pages.

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Automatic Heat and Air Conditiong, Chicago, Ill.	125-127		Publication
Automatic Products Co., Milwaukee, Wis.	209	R. W. Johnson, W. E. Schuetz, E. A. Vallee, Donald Tmey	Automatic controls for air conditioning, commercial refrigeration and heating, including expansion valves, solenoid valves, thermostats, humidity regulators, draft regulators, constant level oil valves
Automatic Valve Corp., Chicago, Ill.	637		Valves
Autovent Fan & Blower Co., Chicago, Ill.	123	J. C. Donaldson, H. Stai, L. Ward, G. J. Kalwitz, C. E. Wandas, J. E. Truitt, E. Ackerman, C. E. Clague, Tom Brown	Propeller fans, unit heaters, volume blowers, louvres
Baker Ice Machine Co., Omaha, Neb.	134	Burge Ice Machine Co., Inc.	Four-cylinder "Freon" compressor unit
Baldor Electric Co., St. Louis, Mo.	142	O. A. Baumann, E. W. Bruce, D. Halliday	Electric motors for air conditioning in constant and variable speed types
Barber-Colman Co., Rockford, Ill.	503	R. P. Dewey, C. J. Braatz, T. K. Greenlee, D. J. Stewart, E. S. Huffman, H. E. Shugars, W. J. Foley, D. R. Farquhar, L. C. Plaehn, C. F. Hayden, H. C. Shilling, R. H. Wittbold, R. L. Deppmann, Barton D. Wood, R. S. Bohn, G. W. Bohn, C. N. O'Day	Electric system of temperature and humidity control, grilles and registers. Air conditioning controls for complete control of temperature, moisture content, direction, diffusion and aspiration of air
Barnes & Jones, Inc., Boston, Mass.	30	W. S. Andrews, E. R. Barkley	Vacuum heating specialties
Beaver Pipe Tools, Inc., Warren, O.	131		Pipe cutting; threading and reaming tools and machines
Bell & Gossett Co., Chicago, Ill.	22-24	E. J. Gossett, C. E. Pullum, R. E. Moore, B. A. Bornquist, Al. Olander, P. P. Wolff	Indirect water heaters, circulators, submerged heaters, motorized valves, hot water heating specialties
Bethlehem Steel Co., Bethlehem, Pa.	720-722-724	A. A. Warg	Sheets for air-conditioning systems and steel pipe for heating systems
Breuer Electric Mfg. Co., Chicago, Ill.	519	C. A. Bremmer, D. E. Campbell, R. G. Breuer	Furnace and boiler vacuum cleaners, portable electric blowers
Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.	310-312-314	F. A. Mudgett, C. L. Saunders, L. M. Morley, R. A. West, R. L. Goetzenberger, H. M. Schmitt	Recording and automatic control instruments for relative humidity, temperature, pressure and flow, including both electrically and air-operated valves
Bryant Heater Co., Cleveland, O.	1	J. N. Crawford	Dehumidifier, winter air conditioner, humidifier, boiler, dualator
Buffalo Forge Co., Buffalo, N. Y.	543	C. C. Cheyney, C. A. Booth, E. F. Wendt, L. D. Emmert, S. M. Trumbo	Fans, unit heaters, air washers
Burdett Mfg. Co., Chicago, Ill.	231-233	James A. Lytle, T. Tesmer, R. Cleveland, J. E. Orr, C. F. Petersen	Radiant heat gas burners for space heating; manual proportioning control valves and proportional mixers
Burge Ice Machine Co., Chicago, Ill.	134		Air conditioning equipment for industrial plants, florists, offices, homes, restaurants, etc. See Baker Ice Machine Co.
Burgess Battery Co. (Acoustic Div.), Chicago, Ill.	416	B. S. Reynolds, E. A. Sipp, W. Manning, R. Horrigan	Acoustic duct lining
Burke Stoker & Mfg. Co., Chicago, Ill.	344-346		Stokers
Burnham Boiler Corp., Irvington, N. Y.	434-436	A. E. Bastedo, A. P. Weiss, J. Balter, V. A. Good, A. F. Johnson	Boilers, radiators, tank heaters, air and vacuum valves, unit heaters
Carbondale Machine Corp., Harrison, N. J.	606	T. E. Carpenter, T. J. Atkins	Refrigeration condensing units; vertical-mounted air conditioning unit; suspended and floor type room coolers
Carnegie-Illinois Steel Corp., Chicago, Ill.	52-53		Steel products
Carrier Engineering Corp., Newark, N. J.	338-340-342		Air conditioning equipment
Carter Coal Co., Cincinnati, O.	311		Coal
Cashin Co., W. D., Boston, Mass.	25-27-29		Valves
Century Electric Co., St. Louis, Mo.	210	A. E. Schmitt, H. A. Porter, H. L. Madsen, H. J. Paul, R. J. Russell, Geo. Smith, C. H. Lankford, G. C. Henderson, G. H. Hodgskiss, Oliver S. Imes	Single phase and polyphase motors, especially adapted for use in air conditioning and refrigeration, multispeed, high torque and quiet
Century Engineering Corp., Cedar Rapids, Ia.	528-530	J. A. Lattner, M. D. McWilliams, E. J. Lattner	Air conditioner furnace unit; boiler-burner unit; oil burning water heater; full line of oil burners
Chace Valve Co., W. M., Detroit, Mich.	119	J. C. Schwab, S. R. Hood, B. A. Paulsey	Thermostatic bimetals
Chalmers Oil Burner Co., Minneapolis, Minn.	738		Oil burners
Chapman Clay Co., Zanesville, O.	13	A. L. Byfield, Harry Himelblau, G. H. Enteman, S. L. Bartlett, H. S. Bowers, W. P. Dosey	Furnace lining; cast refractory; stucco

Introducing for the first time at this show....New series of thermo valves by **Alco Valve Co., Inc.**, St. Louis, Mo.... New unit heater by **American Blower Corp.**, Detroit, Mich., the first to have decibel ratings....New air conditioners, air filters, rapid venting valve with half-inch venting port for use on steam mains and an adjustable orifice venting valve for radiators on one-pipe steam and vacuum heating systems, all by **American Radiator Co.**, New York, N. Y....The world's largest stainless steel polished sheet, 84x90 in., mirror finish, by **American Rolling Mill Co.**, Middletown, O. ....New propeller fan embodying a non-overloading power feature by **Autovent Fan & Blower Co.**, Chicago, Ill.... Improved type tankless heater and many innovations in hot water heating specialties by **Bell & Gossett Co.**, Chicago, Ill. ....A high power valve operator made for either high or low voltage operation and a new oil-immersed damper control motor rated at 1,000 lb-in. torque, both by **Barber-Colman Co.**, Rockford, Ill....A compact, close-coupled cen-


"The Big Week"
• Chicago •
January 27-31
To reach the International Amphitheatre from the Palmer House by surface lines take car marked "Racine-87th" on State St. direct (fare, 7c); by elevated, walk south on State two blocks to Van Buren, board any southbound train to Indiana Ave., change at Indiana for Halsted St. station at the Amphitheatre (fare, 10c). Special motor coach from Palmer House to Amphitheatre, fare 15c. Taxi, 25c per person when five ride.
To drive to Amphitheatre, go south on Michigan Ave. to 39th or 43rd, turn right to Halsted (see map); or drive west on Washington (which is two blocks north of hotel) to Canal St., south on Canal to Archer, southwest on Archer to Union Ave., south on Union to Root, west on Root to Amphitheatre. Free parking for 6,000 cars available at Amphitheatre.
STOCK YARDS
INTERNATIONAL AMPHITHEATRE
HALSTED ST.
HALSTED STREET
ROOT ST.
UNION AVE.
43RD STREET
39 TH. STREET
35TH STREET
31 ST. STREET
ARCHER AVE.
CANAL STREET
CHICAGO RIVER
STATE ST.
ARMOUR INSTITUTE OF TECHNOLOGY
STATE STREET
MICHIGAN AVE.
UNION STATION
C.B.N.W. RY.
MERCHANDISE MART
GRAND CENTRAL STATION
LA SALLE ST. STATION
PALMER HOUSE HOTEL
TOWER BLDG.
DEARBORN ST. STATION
ILLINOIS CENTRAL STATION
STEVENS HOTEL
ART INSTITUTE
SOLDIERS FIELD
FIELD MUSEUM
GRANT PARK
ADLER PLANETARIUM
NAVY PIER
KEY
ELEVATED ROADS
AUTO ROUTES
SURFACE LINES
LAKE MICHIGAN
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Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Chase Brass & Copper Co., Waterbury, Conn.	228–230		Copper products
Chicago Pump Co., Chicago, Ill.	432	M. I. Weil, H. E. Martin, E. A. Ehrlich, L. P. Blattner, J. Obermaier, D. Boyell	Return line vacuum pump for heating systems, condensation pump and receiver, horizontal split case double suction pumps, new close-coupled pumps (motorpump type)
City of Chicago, Board of Health	804–806	Herman N. Bundesen, M. D.; Hugh O. Jones, M. D.; Joel I. Connolly, John J. Aeberly, Mathew J. Martinek	Working model illustrating water contamination by a cross-connection of an ice machine condenser and sewer, and syphonage from a fixture
City of Chicago, Dept of Smoke Inspection and Abatement	804–806	H. D. Blackwell	Displays on proper firing of coals
Columbia Steel Co., San Francisco, Cal.	52–53		Steel products
Cook Electric Co., Chicago, Ill.	515	G. R. Folds, J. S. Baker, J. F. Jaap, A. M. Wilkins, R. Schultz.	Thermostatic controls for domestic heating plants; zone controls; vapor motors; automatic valves; metal bellows
Cork Import Corp., New York, N. Y.	641	Wm. E. Stewart, G. H. Drake, A. R. Wienke	Cork insulation, cork machinery isolation
Crane Co., Chicago, Ill.	204	W. K. Glen, C. A. Olson, George Larson, W. H. Baker, Jr., J. Rosen, J. Magos	Oil-burning boilers, coal-fired boilers, gas-fired boilers, conversion burners, radiation, valves and fittings
Crowe Nameplate & Mfg. Co., Chicago, Ill.	816		Dials and nameplates
Cyclone Fence Co., Waukegan, Ill.	52–53		Steel products
Dail Steel Products Co., Lansing, Mich.	15	A. L. Byfield, Harry Himelblau	Systems of heating, cooling and air conditioning
Dayton Rubber Mfg. Co., Dayton, O.	427	L. C. Strobeck, T. C. Davis	V-belt drives
De La Vergne Engine Co., Philadelphia, Pa.	33		Pumps
Delco Appliance Corp., Rochester, N. Y.	520–522		Winter air conditioner, oil burner, boiler
Detroit Lubricator Co., Detroit, Mich.	504	A. G. Hann, C. J. Swan, E. J. Doucet, K. B. Thorndike, L. O. Grauer, G. A. Wegner, J. S. Snyder, R. L. Campbell, J. F. McKenna, I. J. Knudson, K. Symonds, P. S. Russel	Mechanical and electrical controls for oil burners, gas burners, stokers, refrigeration and air conditioning
Dole Valve Co., Chicago, Ill.	418	F. Lund, Stuart G. Phillips, F. M. Thomson, A. L. Toll, Chas. O. Pratt	Air and vacuum valves
Domestic Engineering, Chicago, Ill.	125–127		Publication
Dreis & Krump Mfg. Co., Chicago, Ill.	742		Sheet metal tools
Dunham Co., C. A., Chicago, Ill.	428 & 527–529–531	William Zingheim, W. J. Mauer, George Mansinger, F. E. Schmidt, C. M. Brigham, Oliver J. Prentice, A. J. Dickey, H. D. Henion, M. W. Shears, D. McCrimmon	Differential vacuum heating system, unit heaters, concealed radiators
Eagle-Picher Sales Co., Cincinnati, O.	212	E. R. Stevens	Plastic insulation, blanket insulation, home insulation, asbestos cement, weather-proofing cement
Economy Pumping Mchy. Co., Chicago, Ill.	107–109–111	R. H. Thomas, L. G. L. Thomas, W. W. Huggins, H. R. Ryan, A. W. Kerr, L. M. Nechine, D. E. Dudley	Double suction centrifugal pumps; sewage pumps; close-coupled centrifugal pumps
Eddy Stoker Corp., Chicago, Ill.	643		Stokers
Electric Air Heater Co., Div. American Foundry Equiment Co., Mishawaka, Ind.	625	H. A. Soverhill, E. L. Rostiser, James Shamo, Martin H. Kidder	Industrial, portable and built-in electric air heaters
Electrimatic Corp., Chicago, Ill.	707	H. S. Dekker, C. F. Toussaint, E. M. Toussaint, H. L. Beekley.	Pressure, temperature and electrically operated valves; water regulators; refrigerant control and regulating valves; safety blow-off valves for refrigerant and steam
Electrol, Inc., Clifton, N. J.	605		Oil burners
Ellison Draft Gage Co., Chicago, Ill.	141	Lewis M. Ellison	Air filter gages, pitot tubes, draft gages, portable gas analyzers, steam calorimeters
Emerson Elec. Mfg. Co., St. Louis, Mo.	410–509	M. C. Miller, L. F. Blough, R. E. Otto, T. Egan, W. C. Davis, J. A. Rodgers	Motors, exhaust fans, ventilating fans, furnace blowers, furnace fans, air circulators
Enterprise Boiler & Tank Wks., Chicago, Ill.	642	E. J. Schimke, M. J. Hirsch, B. J. Strege	Mechanical built-in heater with filters, controls, humidifier and blower; furnaces
Evans Corp., Geo., Moline, Ill.	624	Wm. F. Evans, Reid Evans, Clark W. Warfield	Winter air conditioner for use with fuel oil or gas
Excelsior Steel Furnace Co., Chicago, Ill.	736	C. E. Glessner, F. E. Ford, A. B. Glessner, J. J. Holub, C. Kolar, P. Crowley, Carl Gustavson	Furnaces; air conditioning unit; rectangular forced-air ducts and fittings; warm air furnace pipe and fittings; gas vent and flue pipe and fittings
Excelso Products Corp., Buffalo, N. Y.	6–7	C. W. Farrar	Indirect water heaters; tankless heaters; mixing and cleaning valves

trifugal pump, 3 to 600 gpm against heads up to 189 ft, by **Chicago Pump Co.**, Chicago, Ill....A new type thermostat by **Detroit Lubricator Co.**, Detroit, Mich....A new asbestos cement for setting up furnaces, stoves and retorts by **Fireline Stove & Furnace Lining Co.**, Chicago, Ill....In celebration of the beginning of its 50th anniversary, new oil- and coal-fired residential steel boilers, equipped with domestic hot water coils for summer and winter use, by **Fitzgibbons Boiler Co.**, New York, N. Y....A coal-burning and a gas-fired air conditioning furnace unit by **Fox Furnace Co.**, Elyria, O....A new 20 ton low pressure refrigerating unit with four cylinders arranged in a V-pattern, one of a pair of machines just brought out by **Frick Co.**, Waynesboro, Pa., the smaller one with three cylinders and a 15 ton capacity....Effective temperature control instruments; a "windowstat," an instrument which provides protection against window condensation during cold weather; and a new hand-aspirated psychrometer by **Julien P. Friez & Sons, Inc.,**

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Fairbanks, Morse & Co., Chicago, Ill	239 & 140	W. H. Wallbaum, W. J. Burchill, T. B. R. Peters, F. F. Stevenson, W. G. Kenyon, H. L. Bilsborough, Warren Johnson, L. G. Briggs, C. R. Booth	Automatic coal burners for homes, apartments and commercial establishments; floor type, wall type and ceiling suspension type air conditioning units for homes, stores, offices, etc.; refrigeration compressor unit
Fedders Mfg. Co., Inc., Buffalo, N. Y	610	E. R. Walker, Marc Shantz	Unit heaters and refrigeration units
Federal Housing Administration		Edw. T. Mead	Literature and posters on modernization credit
Fee and Stemwedel, Inc., Chicago, Ill	135	R. L. Fee, A. L. Stemwedel, H. Smiley	Thermometers, barometers, humidity indicators
Fireline Stove & Furnace Lining Co., Chicago, Ill.	113		Furnace lining, furnace cement and refractory materials
Fitzgibbons Boiler Co., Inc., New York, N. Y.	307	Paul K. Addams, Ray C. Malvin	Steel heating boilers for residences and commercial buildings
Fox Furnace Co., Elyria, O	4–5	C. A. Olsen, M. M. Suppes, J. E. Maynard, Geo. Boeddener, E. P. Hayes, E. C. Harr, F. C. Evans, M. H. Klett, W. L. Tulburt	Gas-fired air conditioning unit operating with zone control; oil burning air conditioner with operating refrigerating machine to demonstrate cooling; oil burning air conditioning unit; coal burning air conditioning unit
Frick Co., Inc., Waynesboro, Pa	128	W. H. Aubrey, A. N. Chandler, F. R. Zumbro, J. H. Carter, A. E. Roebke, Van J. Sparks, S. C. Bloom, T. C. McKee	Refrigerating machinery designed for air conditioning work
Friez & Sons, Inc., Julien P., Baltimore, Md.	320	Denis McCormack, Kenneth E. Whitney, Irving Willett, Richard P. Sunderland, Lucien L. Friez	Humidistats, thermostats, effective temperature control instruments, electrical relays, humidity and temperature indicators, air meters, psychrometers, anemometers, recording instruments, instrument for protection against window condensation
Frigidaire Corp., Dayton, O	441–443–445		Refrigeration and air conditioning equipment
Fuel Oil Journal, New York, N. Y	333–335		Publication
Furblo Co., Hermansville, Mich	536	I. W. Rowell, A. R. Meiche, G. A. Voorhees	Package units and a blower suitable for use by furnace manufacturers for complete mechanical heating units
Garden City Fan Co., Chicago, Ill	517	G. L. Heck, W. Gardner	Fans and blowers
Gaskoal Corp., Chicago, Ill	640		Domestic heating plant using pulverized coal as fuel
General Electric Co., Bloomfield, N. J	2		Oil furnaces, gas furnaces, air conditioning units, warm air conditioners, store coolers, condensing units, room air conditioners
Gilbert & Barker Mfg. Co., Springfield, Mass.	709–711	S. C. Hope, H. F. Tapp, E. J. Enoch, E. R. Walsh, Jr., W. C. Leitch, D. C. Elliott	Complete line of oil burners, air conditioning units and boiler-burner units
Grinnell Company, Inc., Providence, R. I.	25–27–29	H. P. Conway, A. W. Moulder, D. O. Anderson, A. B. Donkersley, L. A. Dunbar, W. Becker, J. F. Paus, A. E. Nordahl, C. L. McGinnis, T. R. Horan, H. F. Meyers	Unit heaters, air conditioning units, welding fittings, traps and heating specialties, adjustable pipe hangers, cast and malleable iron fittings, convectors, automatic sprinklers
Hardinge Oil Burner Co., Chicago, Ill	9	W. J. Price, F. O. Shoemaker	Oil burners; pressure burners; rotary burners; boiler-burner unit; oil-burning furnace air conditioning unit
Hart & Cooley Mfg. Co., Chicago, Ill	309		Directional air conditioning registers and grilles
Health-air Systems, Inc., Detroit, Mich	60		Furnace air conditioning unit
Heating & Ventilating, New York, N. Y	224		Publication
Heating, Piping and Air Conditioning, Chicago, Ill.	322–324	Keeney Publishing Co	Publication
Heil Co., Milwaukee, Wis	207	Julius P. Heil, Joseph F. Heil, C. B. Tamm, H. F. Pugh, C. C. Walton, George Hochstein, John Kunzelman, H. C. Frentzel	Furnace-burner units, boiler-burner units, oil burners
Henry Furnace & Fdry. Co., Cleveland, O	708		Air conditioning furnace units, sheet metal ducts and fittings
Henry Valve Co., Chicago, Ill	627		Refrigeration valves and fittings
Hennsey De-Concentrator Co., Watertown, Wis.	13	A. L. Byfield, Harry Himelblau	Feed water meters and hot water meters
Hess Warming & Ventilating Co., Chicago, Ill.	628		Warm air furnaces and air conditioning units
Hexcel Radiator Co., Racine, Wis	17	J. G. Zummach, Lee Larson	Hot water portable electric room heater; portable electric humidifier

Baltimore, Md....A completely automatic coal burning heating plant, using pulverized coal, by **Gaskoal Corp.**, Chicago, Ill....A portable electric humidifier and a portable electric room heater by **Hexcel Radiator Co.**, Racine, Wis....A line of radiator traps and combination float and thermostatic traps by **Illinois Engineering Co.**, Chicago, Ill....A new duct jet for direct reading air velocity meter by **Illinois Testing Laboratories, Inc.**, Chicago, Ill....A six stage air conditioning furnace unit by **Joliet Heating Corp.**, Joliet, Ill....Air-acoustic sheets, a new product developed by **Johns-Manville**, New York, N. Y., for use in quieting ducts of air conditioning systems....Stock factory made forced air fittings by **Lamneck Products, Inc.**, Columbus, O....New line of blower wheels and housings by **Lau Heating Service, Inc.**, Dayton, O.... A humidifier water control, new low water cut-off by **McDonnell & Miller**, Chicago, Ill....New type oil fired winter air conditioning furnace unit by **Meyer Furnace Co.**, Peoria, Ill....An oil fired air conditioning furnace and a

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Himelblau, Byfield & Co., Chicago, Ill	11–13–15	A. L. Byfield, Harry Himelblau, Wm. P. Dosey, F. C. Peterson, S. L. Bartlett, H. S. Bowers, G. H. Enteman, R. E. Anderson	See Alco Valve Co., Airtherm Mfg. Co., Chapman Clay Co., Dail Steel Products Co., Henszey De-Concentrator Co., Korfund Co., Midwest Piping & Supply Co., Turney Corp.
Hoffman Specialty Co., Inc., New York, N. Y.	107–109–111		Venting valves, supply valves, thermostatic traps; vacuum and condensation pumps; zoned controlled heat systems
Holcomb & Hoke Mfg. Co., Indianapolis, Ind.	712–714	P. F. Kuhlman, De Young, E. J. Ostermeier, A. H. Vigdor, Carl Hoebner, E. M. Brackett, C. W. Stumpf	Stoker
Holtzer-Cabot Electric Co., Boston, Mass	241	F. P. Dismore, W. R. Fraser, R. C. Gault	Motors and controls for air conditioning apparatus, unit heaters, oil burners, blowers and fans
Hotstream Heater Co., Cleveland, O	136	L. R. Mendelson, Geo. G. Gebhart, Chas. F. Stumpf	Commercial and industrial draft controls; indirect heaters; summer and winter control for hot water installations; large volume water heating units
Howe Ice Machine Co., Chicago, Ill	23	H. B. Howe, C. W. Howe, C. J. Freestone	"Freon" condensing unit operating on ceiling type comfort cooling unit; 1 H.P. condensing unit; air cooling coil; compressor parts
Ilg Electric Ventilating Co., Chicago, Ill	124	Byron Casey, Harry Lagodzinski, Alfred DeSmet, Jack Worsdell, Milton Arenberg, C. W. Dexter	Spot cooler; ceiling-type cooling unit; blower with variable air controller; volume blower; self-cooled motor propeller fan
Illinois Engineering Co., Chicago, Ill	321-323	J. L. Ehretsman	Line of steam heating specialties and zone control equipment for heating systems. Glass model high pressure steam trap working under steam
Illinois Iron & Bolt Co., Chicago, Ill	728		Stokers
Ill. Testing Laboratories, Inc., Chicago, Ill	419	M. D. Pugh, J. F. Inman, J. A. Obermaier	Direct-reading air velocity meters; distant-reading thermometers; pyrometers and accessories
Imperial Brass Mfg. Co., Chicago, Ill	337		Welding equipment
Independent Register Co., Cleveland, O	318	E. C. Fox, Blair A. Quick, B. N. Richardson	Forced air and conditioned air registers and grilles
Ingersoll-Rand Co., New York, N. Y	446	E. L. Champion	Water vapor refrigeration
Iron Fireman Mfg. Co., Cleveland, O	308	H. H. Kurtz, William O'Neil	Automatic coal burners for residences and small commercial jobs; stokers for large commercial-industrial jobs
Iroquois Coal Co., Indianapolis, Ind	712–714	P. F. Kuhlman, DeYoung, E. J. Ostermeier, A. H. Vigdor, Carl Hoebner, E. M. Brackett, C. W. Stumpf	Holcomb & Hoke stoker
Jenkins Bros., New York, N. Y	214–216		Valves
Johanson Water Heater Co., Chicago, Ill	139	Russell W. Johanson	Submerged water heaters, oil preheaters, steam coil heaters
Johns-Manville, New York, N. Y	110		Rock wool home insulation; industrial insulation products; duct insulation sheets
Johnson Co., S. T., Oakland, Cal	510	J. C. Johnson, F. C. Staples, Daniel E. Johnson, M. R. Groble	Rotary oil burners, water heaters and house heating combination units
Johnson Service Co., Milwaukee, Wis	521–523	P. D. Gayman, C. A. Storch, F. R. Jelinek	Automatic temperature control systems for heating, cooling, ventilating and air conditioning
Joliet Heating Corp., Joliet, Ill	638	E. J. Huber, R. W. Menk, Lee Colburn, Jacques Tyrol	Steel furnaces; air conditioners
Jones & Laughlin Steel Corp., Pittsburgh, Pa.	208	W. H. Wiewel, H. L. Miller, M. A. Blessing, A. E. Crockett, G. C. Shidle, I. A. Mlodoch, J. F. Weidlin, B. J. Irwin	Seamless and welded pipe; hot rolled seamless steel boiler tubes; flat and cylindrical coils, joints made with seamless pipe; construction products
Kainer & Co., Chicago, Ill	415	H. W. Butsch	Governors, relief valves, reducing valves, strainers
Keasbey & Mattison Co., Ambler, Pa	437	R. C. Nelson, J. R. Adams, J. L. McGregor, H. N. Berger, H. F. Brammann, W. A. DeVaney, R. M. Dewar, F. T. Dolen, S. M. Durham, H. C. Green, R. W. Sanders, W. A. Ross, S. W. LeFager	Insulations
Keeney Publishing Co., Chicago, Ill	322–324	F. P. Keeney, W. J. Osborn, R. P. Wettstein, C. E. Price, R. A. Jack, C. M. Burnam, Jr., J. D. Wilder, F. Kottra, J. D. Thomas.	Publications and books on air conditioning
Kelvinator Corp., Detroit, Mich	55–56–57	J. K. Knighton, J. S. Garceau	Refrigeration condensing units; air conditioning units, including self-contained and floor type cabinet models, suspended type models and cooling coils; conversion type oil burners and boiler-burner units

gas fired boiler by **L. J. Mueller Furnace Co.**, Milwaukee, Wis....Copper tube and fin heat transfer surface employing two steam distributing tubes inside each of the regular condensing tubes by **John J. Nesbitt, Inc.**, Philadelphia, Pa.... First group of new automatic controls for heating, ventilating, air conditioning and refrigeration by **Perfex Controls** Co., Milwaukee, Wis....A double reservoir, the upper entirely separate from the lower, self aligning, self lubricating pillow block by **Randall Graphite Products Corp.**, Chicago, Ill....A new spray humidifier with new self cleaning spray nozzle for use with warm air furnaces by **Rega Mfg. Co.**, Rochester, N. Y....A domestic humidifier for installation in the smoke pipe of a warm air furnace by **Rochester Mfg. Co., Inc.**, Rochester, N. Y....New oil burner controls, new stoker controls and a new dehumidifying liquid by **Russell Electric Co.**, Chicago, Ill....Graduator system of tempera-

Kewanee Boiler Corp., Kewanee, Ill	502–504	Art Hare, A. B. Martin	Round type boiler with round jacket for residence heating with coal, equipped with hot water heating coil; round type boiler with square jacket for residence heating with oil, equipped with hot water heating coil; square type boiler with jacket for residence heating with oil, equipped with hot water heating coil; boiler for heating larger buildings with coal.
Kleen-Heet, Inc., Chicago, Ill	512–514	J. H. Hirsch, E. J. Reller, Joseph Hirsch, E. A. Weil, W. J. Sarrasin	Gun-type burners; automatic water heaters; side-arm water heaters; range burners; boiler-burner units
Korfund Co., Long Island City, N. Y	13	A. L. Byfield, Harry Himelblau	Isolation materials
Lamneck Products, Inc., Columbus, O	237	Perl S. Miller, C. M. Butler, H. R. Jones, B. K. Paget	Tin double and single wall stack and fittings; tin round pipe, angles, elbows, register pans; galvanized round pipe, angles, elbows, register pans, cold air boots and other fittings; galvanized adjustable furnace caps; galvanized forced air trunk line ducts and fittings; galvanized forced air stack and fittings; registers and grilles
Lau Heating Service, Inc., Dayton, O	313	E. B. Lau, W. F. Gaul	New package unit blower; new blower assembly; blower wheels and housings
Lennox Furnace Co., Marshalltown, Ia	633–635	E. N. Stahler, R. D. Strickler	Oil-burning air conditioning furnace
Maid-O-Mist, Inc., Chicago, Ill	137	W. J. Woolley, O. V. Woolley, E. W. Sanborn, A. B. Smith	Automatic humidifiers for warm air furnaces; automatic humidifiers for steam radiators; water-feed valves for humidifier pans on hot water radiator; boiler feeders; low water cut-out; hot water air vents; circulating pumps; pressure reducing valves; pressure relief valves
Marsh Corp., Jas. P., Chicago, Ill	120–122	C. H. Olmsted, B. Scudder, R. T. Hedfield, A. D. Rose, O. W. Hage, E. Kluger, T. Kenney, F. L. Ziccarelli, J. Emmett, C. H. Bevington, W. Yorke, F. Farrant, M. De Grave, H. T. Kucera	Industrial instruments, heating equipment and system of temperature regulation
May Oil Burner Corp., Baltimore, Md	532–534		Oil burners
McCord Radiator & Mfg. Co., Detroit, Mich	417		Unit heaters and heating and cooling surface
McDonnell & Miller, Chicago, Ill	524	E. N. McDonnell, Jack McDonnell, Nils Swanson, Bruce Adams	Boiler water feeders, low water cut-offs, humidifier controls, water feeder cut-off combinations
Mercoid Corp., Chicago, Ill	328–330	J. N. Derby, Jr., J. W. Owens, A. Erickson, R. F. Fisher, A. N. Schultz, A. W. Barr, A. W. Widdowfield, H. A. Matthews	Automatic controls for oil burners, stokers, refrigeration and industrial applications
Meyer Furnace Co., Peoria, Ill	339	George F. Meyer, George Harms, Frank E. Mehrings, Frank L. Meyer, W. E. Lock, H. C. Hoffman, L. M. Baugh, J. B. Sauer, H. L. Jackson, A. R. Lyon, G. A. Kelley, Otto Falkenhainer, W. P. Dennis, C. J. Haintzman.	Domestic warm air heaters, blowers and air conditioning appliances, burning gas, oil, coal or wood
Midwest Piping & Supply Co., St. Louis, Mo	13	A. L. Byfield, Harry Himelblau	Pipe fabrication and welding fittings
Milwaukee Valve Co., Milwaukee, Wis	316	C. S. Bigelow, G. M. Janes, J. G. Gregory	Steam, vapor and vapor-vacuum heating specialties; bronze valves—gates, globes, checks, etc.; valves and fittings for oil burner installation
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.	310–312–314		Automatic controls for heating, ventilating and air conditioning
Modine Mfg. Co., Racine, Wis	227–229	A. G. Dixon, O. E. Desmond, D. Paden, M. J. Druse	Unit heaters, copper radiation
Monarch Mfg. Wks., Inc., Philadelphia, Pa	618	J. M. Carroll, E. B. Frame	Nozzles, valves, strainers, air stabilizers
Motor Wheel Corp., Heater Division, Lansing, Mich.	334–336	Guy Weaver, Gower Chapman, M. F. Cotes	Pressure burners; oil burning furnace for steam or hot water heating; weather control units
Mueller Brass Co., Port Huron, Mich	143		Copper pipe and fittings
Mueller Furnace Co., L. J., Milwaukee, Wis	408	H. P. Mueller, E. A. Jones, R. J. McDonald	Oil-fired air conditioning furnace; gas-fired boiler; gas-fired furnace; gas-fired cabinet type unit; cast iron coal furnace; steel coal furnace; air conditioning unit; fan-filter unit
National Radiator Corp., Johnstown, Pa	31		Convector; gas boiler; boiler-burner unit

ture control designed to control temperature of large buildings directly by the weather by **Sarco Co., Inc.**, New York, N. Y....A tankless hot water heater and a multi-coil indirect heater by **Taco Heaters, Inc.**, New York, N. Y.... New pressure oil burner and new series of oil burning boilers by **Timken Silent Automatic Co.**, Detroit, Mich....A rekindling control with automatic over-heat prevention for stokers and a new line of clock controlled switches for use with single or dual thermostats by **Tork Clock Co., Inc.**, Mt. Vernon, N. Y....A device for use in ducts to permit the use of all right angle elbows throughout the system and a volume control device which also provides uniform distribution of air over a grille surface by **Tuttle & Bailey, Inc.**, New Britain, Conn....New line of diffusional and directional flow air conditioning registers by **United States Register Co.**, Battle Creek, Mich....Oil burning water heater by **Viking Mfg. Co.**, Akron, O....Oil burning furnace and air conditioning unit by **Waterman-Waterbury Co.**, Minne-

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
National Regulator Co., Chicago, Ill.	242		Temperature controls
National Sheet Metal Contractor, Chicago, Ill.	616		Publication
National Tube Co., Pittsburgh, Pa.	52–53		Pipe
Nelson Corp., Herman, Moline, Ill.	130–132		Unit heaters, unit ventilators and air conditioners
Nesbitt, Inc., John J., & Buckeye Blower Co., Philadelphia, Pa.	404	H. Berkley Hedges, D. C. Wiley	Copper heating surface with steam distributing tubes; unit heaters; unit ventilators
Norge Corp., Detroit, Mich.	721–723		Refrigeration equipment
Oil Burner Builders, Rock Island, Ill.	732		Oil burners
Oil Heat, New York, N. Y.	332		Publication
Owens-Illinois Glass Co., Newark, O.	108		Air filters
Peerless Electric Co., Warren, O.	244	W. S. Kingsbury, H. C. Hohmann, Carl H. Larson	Direct-drive blowers; belt-drive blowers; exhaust fans; special motors for air conditioners; power motors —single phase and polyphase
Penn Electric Switch Co., Des Moines, Ia.	218–220	Albert Penn, M. E. Henning, Nelson B. Delavan, Robert H. Luscombe, Burton E. Shaw	Automatic controls for warm air, hot water, steam, vapor and vacuum heating, refrigeration and air conditioning
Peoples Oil Burner Co., Chicago, Ill.	609	J. S. Peoples, W. C. McNitt, L. E. McGiffin, W. R. Van Horne, R. Norbrock, G. Onnen, J. Seninger	Oil burners and conversion burners for water heaters
Perfex Controls Co., Milwaukee, Wis.	541	A. G. Butler, J. K. Luthe, F. D. Hansen, H. E. Lindemann, L. L. Cunningham, V. R. Tate	Automatic controls for heating, ventilating, air conditioning and refrigeration
Perfex Radiator Co., Milwaukee, Wis.	541	L. A. Burch, J. K. Luthe, F. D. Hansen, H. E. Lindemann, L. L. Cunningham, V. R Tate	Unit heaters
Petroleum Heat and Power Co., Stamford, Conn.	629–631	J. H. O'Brien, C. E. Shields, H. W. Dexter, A. E. Hess, L. E. Hodge, W. A. Bulger	Automatic domestic oil burner equipment, industrial oil burner equipment: boiler-burner units; air conditioning units
Petrometer Corp., Long Island City, N. Y.	533		Gages
Plibrico Jointless Firebrick Co., Chicago, Ill.	113		Firebrick and refractory products
Plumbing & Heating Trade Journal, New York, N. Y.	439		Publication
Powers Regulator Co., Chicago, Ill.	317–319	H. C. Mueller	Automatic temperature and humidity control for heating, cooling, ventilating and air conditioning systems
Practical Instrument Co., Chicago, Ill.	609		Recording thermometers and operation recorders of electrical devices
Radiant Products, Inc., Akron, O.	713	H. S. Frasher, J. H. Miller	Automatic oil burning storage hot water heater; gun type power burner
Railway Utility Co., Chicago, Ill.	630		
Randall Graphite Prod. Corp., Chicago, Ill.	610	W. P. Thacher, R. H. Whiteley, C. E. Lowgren, E. A. Lampe, T. Soder, H. C. Whiteley, R. L. Whiteley	Self-aligning, self-lubricating pillow blocks; oil reservoir bushings; bronze safety collars, fibre washers and rubber insulating mountings
Refrigeration & Air Conditioning Institute, Chicago, Ill.	619		Correspondence course on air conditioning
Rega Mfg. Co., Rochester, N. Y.	621	Clarence H. Ager, Harold D. Sternberg	Spray humidifier; self-cleaning spray nozzle; water valve
Republic Steel Corp., Cleveland, O.	438–440–442		Sheets and pipe
Richardson & Boynton Co., New York, N. Y.	106		Furnaces
Ric-wil Co., Cleveland, O.	133–135		Tile and cast iron conduit for underground lines of single or multiple pipes for high and low pressure steam or hot water; water-proof asbestos insulation for underground steam lines; a pre-fabricated self-contained unit steam main
Ridge Tool Co., Elyria, O.	32	C. H. Ingwer, R. E. McChesney, E. C. Bliss, P. A. Walker	Pipe wrenches, dies and stocks, pipe cutters, tubing cutters, pipe vises, pipe and screw extractor
Rochester Mfg. Co., Inc., Rochester, N. Y.	613	C. L. Hastings, Wm. O. Lee, R. A. Klock, L. I. Hall	Domestic humidifier for warm air furnaces, pressure and level gauges
Ruberoid Co., New York, N. Y.	636		Insulation
Russell Electric Co., Chicago, Ill.	407	T. C. Russell, E. W. Ballentine, J. D. Raida, R. T. Berg, F. F. Geiger, W. H. Knoepfle, P. S. Fortier, I. W. Maier	Blowers, integral motor-compressor ¾ ton unit, motors, unit heaters, floor and suspended types, attic and window fans for summer cooling, automatic controls, furnace blower-filter units, winter air conditioning units and new dehumidifying liquid
Sangamo Electric Co., Springfield, Ill.	430		Time switches
Sarco Co., Inc., New York, N. Y.	144	G. B. Burke, E. M. Mittendorff, Vincent McCaffrey, Alvin Smith, E. J. Ritchie, Clement Wells	Specialties for vapor and vacuum steam heating systems, including radiator traps, inlet valves, drip traps, air eliminators, boiler return traps, temperature regulators, etc.

apolis, Minn....Air conditioning unit for use with boiler and radiator heating by **Weil-McLain Co.**, Chicago, Ill.... New close coupled pump by **Weil Pump Co.**, Chicago, Ill.... Instantaneous thermostats for unit heaters and coolers, a dual type thermostat and a new weather control for heating systems by **Wilbin Instrument Co.**, New York, N. Y.... Small, low priced belt driven and direct connected centrifugal pumps and new line of deep well turbine pumps by **Worthington Pump & Machinery Corp.**, Harrison, N. J. ....An indoor cooling tower developed to minimize water consumption on small air conditioning systems and a redesigned air conditioning unit by **York Ice Machinery Corp.**, York, Pa.

In operation or special showing....An illuminated cabinet with magnetic valves arranged for operation shows off the thermo valves of **Alco Valve Co.**, St. Louis, Mo....A special hook-up demonstrates how heat and year 'round supply of domestic hot water can be supplied from one fire at

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Scully Steel Products Co., Chicago, Ill.	52–53		Steel products
Sheet Metal Worker, New York, N. Y.	737		Publication
Silent Glow Oil Burner Corp., Hartford, Conn.	105		Oil burners
Silvercote Products, Inc., Chicago, Ill.	632		
Sims Co., Erie, Pa.	706		Water heaters
Spencer Thermostat Co., Attleboro, Mass.	730		Thermostats
Standard Galvanizing Co., Chicago, Ill.	824		Air conditioning and refrigeration coils
Standard Lime & Stone Co., Baltimore, Md.	622	R. F. Fahy, L. L. Gilday	Rock wool home insulation; pipe covering; blankets; blocks, insulating cement
Stannard Power Equipment Co., Chicago, Ill.	617	J. M. Stannard, Geo. W. Clucas, Jas. J. Hayes, A. O. May, Harry P. Barton, Harold Swanson	Combined vapor turbine and electric vacuum heating pump manufactured by Nash Engineering Co., So. Norwalk, Conn. Also representing American Steam Pump Co., Battle Creek, Mich., and Pomona Pump Co., Pomona, Cal.
Steel & Tubes, Inc., Cleveland, O.	217		Tubes
Sterling Engineering Co., Milwaukee, Wis.	587	C. J. Rice, D. W. Rice	Thermostatic float and thermostatic return and bellows traps; valves; vents; water gauges; temperature controls; motorized valves; water heating system; mixing valves
Stevens-Root Co., Chicago, Ill.	117	H. R. Coleman, C. G. Newton	Circulating pumps; indirect and storage type heaters; control valves; shunt-tees for one-pipe hot water heating systems
Streamline Pipe & Fittings Co., Division of Mueller Brass Co., Port Huron, Mich.	143	J. R. Wightman, W. A. Blessed, Ray Comb, C. E. Berry	Copper pipe and fittings; valves and fittings, tank and tankless units
Sturtevant Co., B. F., Boston, Mass.	327	F. Herlan, F. J. Hamilton, D. J. Julius, C. A. Pavey, A. C. Bartlett, J. F. G. Miller	Fans, unit ventilators
Sundstrand Machine Tool Co., Rockford, Ill.	744	Chas. H. Rystrom, Howard Ekstrom	Fuel unit for oil burners; constant displacement pumps; machine tool feed pumps
Sundstrand Sales Co., Rockford, Ill.	731		Fuel oil pumping units
Surface Combustion Corp., Toledo, O.	232–234–236	C. B. Phillips, Eugene A. Weaver, W. B. Montague, W. J. Grover, R. W. Glenn, W. O. Owen, R. L. Clewell, A. H. Koch	Conversion burners, unit heaters, furnaces, water heaters
Synero-Flame Burner Corp., Hartford, Conn.	728	E. A. Teplow, A. S. Gilbert, F. Stierhoff, H. E. Williams	Oil burners
Taco Heaters, Inc., New York, N. Y.	507	Elwood S. White, Joseph R. Murphy, Robert L. Blanding, James B. Wallace, William B. Schuler	Indirect water heaters, circulators, reducing and relief valves, control fittings, tank and tankless units
Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.	52–53		Steel products
Thermal Units Mfg. Co., Chicago, Ill.	607	S. E. Koplar, E. A. Freudiger, W. R. Henderson, J. E. Watkins	Window air cooling cabinet; floor type air cooling unit; humidifier; refrigerating unit; unit heater; unit cooler
Thrush & Co., H. A., Peru, Ind.	511	Lewis H. Dietz, J. J. Munro, Thos. O. Lanphier, J. G. Gregory	Flow control hot water heating systems and accessories
Timken Silent Automatic Co., Detroit, Mich.	341–343–345	M. J. Roberts, T. A. Crawford, M. B. Ells, L. W. Essex, P. E. Carter, L. J. Lofgren, F. J. Bird	Oil burners, oil-burning boilers, air conditioning oil-furnaces, oil-burning water heaters
Tork Clock Co., Inc., Mount Vernon, N. Y.	734	C. J. White, Geo. W. Kohler	Rekindling controls, time switches, hold-fire controls, intermittent controls for unit heaters
Trerice Co., H. O., Detroit, Mich.	639	J. L. Brackett, John Berghuis, E. N. Shelton, W. T. Bown, H. O. Trerice	Industrial instruments for recording, indicating and controlling temperature; steam traps
Turney Corp., Muskegon, Mich.	13	A. L. Byfield, Harry Himelblau	Humidifiers
Tuttle & Bailey, Inc., New Britain, Conn.	412	C. R. Anderson, G. F. Nightingale	Air conditioning grilles and registers, air control devices, convection heaters
Uni-Flo Corp., Rockford, Ill.	503		See Barber-Colman Co.
United States Radiator Corp., Detroit, Mich.	414–513		Boilers and radiators
United States Register Co., Battle Creek, Mich.	315	C. J. Pearson	Full line of air conditioning registers
United States Steel Corp., New York, N. Y.	52–53		Tubular products, wire products, sheets of all descriptions
Viking Mfg. Co., Akron, O.	713	H. S. Frasher, J. H. Miller	Automatic oil burning storage hot water heater; gun type power burner
Viking Pump Co., Cedar Falls, Ia.	718	C. D. Sadler, J. G. Wyth, C. W. Dennis	Fuel oil burner pumps; fuel oil burner pumping units, including valves and strainers

the booth of **American Radiator Co**....Sheet metal duct work will form a frame around the booth of **American Rolling Mill Co.**, demonstrating fabrication details....The duplex vacuum heating pump of **American Steam Pump Co.** will be in operation and will be "alternated" by controls of **W. P. Whittington, Inc**....A five room house is piped with Neor. tubing and glass bowl radiators to show controlled distribution through a water column with air valves of **Anderson Mfg. Co**....A glass model of the Armstrong trap operating at 5 lb steam pressure shows how the trap handles dirt and air as well as condensate in the booth of **Armstrong Machine Works**, Three Rivers, Mich., with another glass model of the Armstrong trap incorporating the automatic air bypass....A moving exhibit of steel sheets greets the eye at the booth of **Bethlehem Steel Co**....Lights and mirrors are utilized to show the action of a balanced and unbalanced motor and the vibration effect in the booth of **Century Electric Co.**, St. Louis, Mo....At the **C. A. Dun-**

Name of Exhibitor	Booth No.	Representatives in Attendance	Products on Exhibition
Vilter Mfg. Co., Milwaukee, Wis.	26–28		Refrigerating compressors
Waterfilm Boilers, Inc., Jersey City, N. J.	614	John L. Lehman	Steel boiler for automatic firing
Waterloo Register Co., Waterloo, Ia.	623	J. O. Knox, F. C. Oltrogge	Air conditioning registers, register frames
Waterman-Waterbury Co., Minneapolis, Minn.	608	H. G. Cross, J. H. Bazille, A. R. Schwantes, J. P. White, B. D. Watchler, J. Skaaren, W. F. Wanner	Oil burning furnace; air conditioning equipment
Watts Regulator Co., Lawrence, Mass.	118	B. E. Horne, G. B. Horne, J. W. Moore, M. Mercury	Boiler water feeders, low water cut-offs, hot water house heating regulators, water and air pressure regulators and reducing valves, relief valves.
Wayne Oil Burner Corp., Fort Wayne, Ind.	243	C. G. Cleaver, E. H. Berghoff, D. J. Winegardner, E. R. Caylor, Randolph Bard	Oil burners; oil burning air conditioning furnace
Webster & Co., Warren, Camden, N. J.	304	B. F. Lerch, H. F. Marshall, Park W. Stickney, R. G. Rosenbach, F. W. Wren, M. A. Norman	Steam heating specialties, including thermostatic traps, float and thermostatic combination traps, radiator supply valves, packless, modulating and quick-opening; central control heating system; radiation
Webster Electric Co., Racine, Wis.	329–331	S. A. Loeb, A. C. Kleckner, P. G. Crewe, E. M. Ford, B. T. Wiechers, H. E. Fellows	Ignition transformers, pressure pumps, pressure regulating valves, strainers, two-stage fuel units, single-stage fuel units.
Weil-McLain Co., Chicago, Ill.	409–411–413	Martin Weil, Thos. D. Casserly, Ben Broom, Chas. Newport, J. Z. Young, Ed. Anderson, Otto Wurster, Fred France, Wm. Miner, Andy Sheehan	Concealed and cabinet type radiators, boilers, air conditioning unit
Weil Pump Co., Chicago, Ill.	121	N. H. Weil, R. D. Weil, G. W. Weil, R. T. Sheridan, F. Irving, J. E. Vitu	Horizontal centrifugal pumps, vertical sump pumps, sewage ejectors, close-coupled centrifugal pumps, cellar drainers
Westinghouse Electric & Mfg. Co., Mansfield, O.	429–431–433–435		Air conditioning equipment.
White Mfg. Co., St. Paul, Minn.	746		Temperature controls
Whiting Corp., Harvey, Ill.	539	G. W. Warnacutt	Domestic underfeed stoker in operation under a warm air furnace
Whittington & Co., W. P., Indianapolis, Ind.	706	W. P. Whittington, Gordon B. Fisher, Geo. A. Willis, Anthony C. Florek	Pump controls. See also American Steam Pump Co.
Wilbin Instrument Corp., New York, N. Y.	627	P. J. Burrill, J. K. Ewing, G. A. Binz	Electric temperature controls; thermostats; motor valves; weather control
Williams Oil-O-Matic Heating Corp., Bloomington, Ill.	34	W. J. Brevitt, Earl Nesmith, C. U. Williams, W. W. Williams, D. M. Frank, W. A. Matheson	Oil burners, oil-burning water heaters, air conditioning units, refrigerating units
Wilson & Co., Inc., Chicago, Ill.	535	C. W. Becker, T. W. Harrigan, Geo. Watkins, A. G. Stout	Air filters; board form insulation; flexible insulation
Wood Conversion Co., St. Paul, Minn.	416	R. B. Simpson, R. E. Backstrom	Duct insulating covering
Wood Industries, Inc., Gar, Detroit, Mich.	516–518	F. H. Dewey, D. J. Luty, Edward Wood, F. L. Stevens, S. E. Chase	Oilfired furnace-burner units; oil-fired boiler-burner units; oil-fired water heaters; conversion oil burners; complete air conditioning unit
Worthington Pump & Machy. Corp., Harrison, N. J.	606	D. S. Gibson, W. O. Wilson, J. J. Thompson, D. E. Tessendorf	Tank-mounted air compressor; centrifugal pumps; steam pump and receiver set; deepwell pump; multi-V drives; feedwater heater display chart
York Ice Machinery Corp., York, Pa.	112–114–116 and 211–213–215		Indoor cooling towers, air conditioners, "freon" condensing units
York Oil Burner Co., Inc., York, Pa.	538–540	Laurence Knapp, E. I. Kraber, Robert C. Hoffman	Domestic oil burners, burner-boiler units, horizontal rotary burners, forced air furnaces
Young Radiator Co., Racine, Wis.	222	F. M. Young, W. H. Schleck, J. J. Hilt, M. F. May, Earl W. May, Don W. Christensen, Vaughn Hardy, Ernst Witzel, C. E. Pugh, W. F. Bowers, T. A. Lundquist, J. H. Carey, George Wetherill, F. Swansberg, R. C. Malvin, F. Roeder, D. Wallburg	Unit heaters, convection heaters, blast units, commercial heat transfer units, evaporators, heat exchangers, air conditioners
Youngstown Sheet & Tube Co., Youngstown, O.	420–422–424	Myron S. Curtis, William H. Texter	Unions, flat-rolled steel and wrought steel pipe

ham Co. exhibit the various units of equipment will talk and, "speaking for themselves," explain their correlated functions in a Dunham differential vacuum heating system....A refrigerating machine in operation will be attached to one of the **Fox Furnace Co.'s** air conditioning furnace units to demonstrate cooling....Action of the valves, lubricating system and other parts of the **Frick** enclosed type "Freon" compressor can be seen as the machine is turned over slowly by a reduction gear motor and cover plates removed. ....**Julien P. Friez & Sons, Inc.**, has a working exhibit of its instruments with which the visitor, by pressing buttons, can humidify, dehumidify, heat and cool a small glass chamber....An animated device shows the variable venting speeds possible by means of a simple adjustment of **Hoffman Specialty Co.'s** new adjustable orifice vent port on radiator valves....**Holcomb & Hoke Mfg. Co.'s** stoker is in actual operation....A graphic model depicts the operation of **Ingersoll-Rand's** water vapor refrigerating unit....**S. T. Johnson Co.'s** home heating and domestic hot water supply unit is in full operation....In **Jones & Laughlin Steel Corp.'s** booth is a 15 ft operating model of a blooming mill....Active working demonstrations of its humidifiers, water feeders, low water cut-outs and circulating pumps can be seen at the booth of **Maid-O-Mist, Inc**....Visitors can operate

the **Jas. P. Marsh Corp.'s** system of temperature regulation in a model of a miniature building and heating plant, demonstrating the manner in which the control operates with varying outside weather conditions....A miniature restaurant enclosed in glass, attractively lighted, heated, ventilated and completely air conditioned is the main theme of **Minneapolis-Honeywell Regulator Co.'s** exhibit with its standard automatic controls regulating the temperature, humidity, etc., which can be changed at will by the spectator. ....The new copper heating surface of **John J. Nesbitt, Inc.,** is shown under actual operating conditions....The circulation of water through a one pipe main in which shunt tees are installed to demonstrate circulation from main to radiator can be seen in the booth of **Stevens-Root Co**....Th **Sundstrand Machine Tool Co.'s** fuel unit with single-stag pump is in operation with the pump being automatically started and stopped....The display unit of **H. A. Thrush & Co.** demonstrates the operating characteristics of its flow control system....**Viking Pump Co.** is showing its fuel pumping units in operation....Motion displays of **Wilson & Co.'s** air filters are employed....**Worthington Pump & Machinery Corp.** lays special emphasis in its exhibit on actual operating units....A complete working model, built on a scale of ¾-in. to the foot, of **Youngstown Sheet & Tube Co.'s** new 79-inch hot continuous sheet mill dominates this company's booth.

Buckingham Fountain and Michigan Avenue, Chicago

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

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Thermal Properties of Concrete Construction

By F. B. Rowley,* A. B. Algren,** *(MEMBERS)* and Clifford Carlson† *(NON-MEMBER)*

Minneapolis, Minn.

This paper is a report of cooperative research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, *in cooperation with the Portland Cement Association, and the University of Minnesota, and conducted in the Engineering Experiment Station, University of Minnesota.*

THERE is no doubt about the necessity of building high thermal resistance into the outside walls of many of our buildings. It would be a comparatively simple job to get high thermal resistance if this were the only quality required, but most buildings have other requirements which make it necessary to select materials and types of construction which have economic structural properties as well as high resistance. It is usually true that materials with high structural strength have low heat resistance, making it necessary to give special consideration to the methods of using them, and perhaps to add special insulation where thermal resistance is an important factor. Concrete is such a material. It has excellent structural properties, but when the ordinary aggregates are used to build monolithic walls without some consideration as to insulating values, a prohibitive thermal conductivity may result.

The thermal properties of concrete walls may be improved by such methods as changing the nature of the aggregate, constructing the wall with different types of air spaces, applying a special surface finish or adding some insulating material to the wall. The purpose of this investigation was to study the different types of masonry and monolithic concrete construction and to find what practical method might be employed to increase thermal resistance. The investigation has thus far included monolithic and masonry walls, different aggregates, different surface finishes, various types of air space construction and the application of specific insulating materials. Obviously there are many combinations which might be considered, but in the interest of economy the number of walls actually built and tested was limited to representative types.

Aggregates. In general low density aggregates will result in lower thermal conductivity than will high density aggregates. This, however, is not always the case as low density may be accompanied by an excessive porosity which will allow the heat to be transferred through the wall by air circulation. Such a condition may be taken care of in part by the application of some impervious surface finish. This will exclude the surface air, but in extreme cases there may also be circulation of air within the wall itself. In this investigation sand and crushed limestone, sand and gravel, cinders and Haydite were used as aggregates. These were graded as indicated by the description of the individual walls.

*Director of Experimental Engineering Laboratories, University of Minnesota.

**Assistant Professor of Mechanical Engineering, University of Minnesota.

†Research Engr., University of Minnesota.

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Air Space Construction Used. There are two types of air spaces which may be built into a wall. First, the continuous air space as may be provided between two parallel walls; and second, irregular cored out sections as are usually provided in concrete block construction. In the first case all heat conducted from surface to surface must pass directly across the air space, and, if there are no connecting rods which serve as conductors, the efficiency of the air space could be very definitely determined from the known properties of such spaces. In the second case only a part of the heat must pass through the air spaces, the remainder passing through the solid material between the spaces. If the material proper has a high thermal conductivity and if the partitions between the cored out spaces are direct between the two surfaces and constitute a considerable percentage of the wall area, the effectiveness of the air space as an insulator may be very materially reduced. It is difficult to make calculations to determine the thermal conductivity of walls containing irregular air spaces, even though the properties of the material are fairly well established. An efficient air space construction must either provide a continuous space over the full wall area or, if there are paths of solid material between the two surfaces, they should be designed as long and restricted in area as possible. In this investigation parallel or continuous air spaces were provided by constructing walls of parallel monolithic and masonry slabs and by furring out the surface for specific insulating finish. The cored air spaces were those commonly used in standard concrete block construction.

Surface Finish. The effect of surface finish on a wall may be to reduce the normal air filtration into and out of the wall and thus improve the internal conductivity by eliminating convection currents, or to change the character of the surface and thereby change the surface coefficient of conductance. If the surface finish should be of material thickness and of an insulating value in itself, it would add to the thermal resistance of the wall. The surface finishes used in this investigation were for the purpose of reducing any interchange of air through the boundary surfaces rather than for improving the surface conductance.

Insulation. There are several methods by which thermal resistance may be built into a wall. As discussed previously, air space construction may be used for this purpose or specific insulating materials may be applied to the walls either in air spaces or on the surface. The effectiveness of any application will depend upon the amount of heat which must normally flow through the insulation. Thus, if insulating material is placed over

Table 1—Masonry Walls—Description and Data

Wall No.	Type of Aggregate	Description of Block	Density of Material in Blocks Lb/Cu Ft	% Percentage of Core Volume	Overall Thickness of Wall in Inches	Inside Surface Finish	Outside Surface Finish	Additional Insulation in Wall	Density of Insulating Material Lb/Cu Ft	Weight of Insulating Material per Sq Ft of Wall Area Exclusive of Surface Finish	Aggregate Used in Wall Percent by Weight	Fineness Modulus of Aggregate			Dry Rodded Weight of Aggregate Lb per Cu Ft		Mix Proportion Dry Rodded Volume	Water-Cement Ratio W/C Gal/Sack	28 Day Compressive Strength Air Dried					Percent Absorption at 28 Days	
																			Area of Specimen Sq In		Total Breaking Load Lb	Breaking Load Lb/Sq In			
												Fine	Coarse	Combined	Fine	Coarse			Gro	Net		Gro	Net	By Wt	By Vol
1a	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Core	86.2	39.8	7.88	As Laid	As Laid	None	.....	.....	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
1b	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Core	86.2	39.8	7.88	As Laid	Two Coats Waterproofed White Portland Cement Paint	None	.....	.....	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
1c	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Core	86.2	39.8	7.88	As Laid	Two Coats Waterproofed White Portland Cement Paint	Coarse Filled with Granulated Cork	5.12	1.34	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
1d	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Core	86.2	39.8	7.88	As Laid	Two Coats Waterproofed White Portland Cement Paint	Core Filled with Dry Cinders	69.7	18.29	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
1e	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Core	86.2	39.8	7.88	As Laid	Two Coats Waterproofed White Portland Cement Paint	Cores Filled with Rock Wool	14.21	3.73	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
1f	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Cores	86.2	39.8	9.38	½ in. Plaster on Metal Lath Furred 1 in.	Two Coats Waterproofed White Portland Cement Paint	Cores Filled with Rock Wool	14.21	3.73	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
1g	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Core	86.2	39.8	8.38	½ in. Plaster Applied Direct	As Laid	Cores Filled with Rock Wool	14.21	3.73	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
1h	Cinder Block	8 in. x 8 in. x 16 in. 3-Oval Core	86.2	39.8	9.88	½ in. Insulation Board Furred 1 in.	½ in. Plaster Applied Direct	Cores Filled with Rock Wool	14.21	3.73	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	8.75	124.9	75.13	99,263	795	1321	14.2	19.7
2a	Haydite Block	8 in. x 8 in. x 16 in. 3-Oval Core	67.7	39.6	7.91	As Laid	As Laid	None	.....	.....	100 Percent Haydite 64 Percent Size A	2.76	5.94	3.92	58	43	1:8½	10.82	125.5	75.75	97,780	779	1289	24.4	25.5
2b	Haydite Block	8 in. x 8 in. x 16 in. 3-Oval Core	67.7	39.6	7.91	As Laid	Two Coats Waterproofed White Portland Cement Paint	None	.....	.....	36 Percent Size B by weight	2.76	5.94	3.92	58	43	1:8½	10.82	125.5	75.75	97,780	779	1289	24.4	25.5

Table 1—Masonry Walls—Description and Data—Continued

Wall No.	Type of Aggregate	Description of Block	Density of Material in Blocks lbs/cu ft	Percentage of Core Volume	Overall Thickness of Wall in Inches	Inside Surface Finish	Outside Surface Finish	Additional Insulation in Wall	Density of Insulating Material lb/cu ft	Weight of Insulating Material per Sq Ft of Wall Area Exclusive of Surface Finish	Aggregate Used in Wall Percent by Weight	Fineness Modulus of Aggregate			Dry Rodded Weight of Aggregate Lb per Cu Ft		Mix Proportion Dry Rodded Volume	Water-Cement Ratio W/C Gal/Sack	28 Day Compressive Strength Air Dried				Percent Absorption at 28 Days	
																			Area of Specimen Sq In		Total Breaking Load Lb	Breaking Load Lb/Sq In			
												Fine	Coarse	Combined	Fine	Coarse			Gro	Net		Gro	Net	By Wt	By Vol
3a	Sand Gravel Block	8 in. x 8 in. x 16 in. 3-Oval Core	126.4	39.8	7.88	As Laid	As Laid	None	.....	.....	73 Percent Sand 27 Percent Pea Gravel by Weight	3.22	5.68	3.91	108	105	1:10	8.92	124.9	75.18	137,440	1100	1829	8.3	16.7
3b	Sand and Gravel Block	8 in. x 8 in. x 16 in. 3-Oval Core	126.4	39.8	7.88	As Laid	Two Coats Waterproofed White Portland Cement Paint	None	.....	.....	73 Percent Sand 27 Percent Pea Gravel by Weight	3.22	5.68	3.91	108	105	1:10	8.92	124.9	75.18	137,440	1100	1829	8.3	16.7
4a	Limestone Block	8 in. x 8 in. x 16 in. 3-Oval Core	134.3	40.2	7.83	As Laid	As Laid	None	.....	.....	78 Percent Limestone Screenings 22 Percent Pea Size Limestone by Weight	3.33	5.89	4.00	111	94	1:9	9.92	123.6	73.88	198,050	1602	2683	7.9	17.0
5a	Cinder Block	8 in. x 12 in. x 16 in. 3-Oval Core	86.2	40.2	11.88	As Laid	As Laid	None	.....	.....	100 Percent Cinders ½ in. to 0	4.05	.....	4.05	63	.....	1:8	12.30	188.5	112.8	154,557	820	1369	14.4	19.9
6a	Sand and Gravel Block	8 in. x 12 in. x 16 in. 3-Oval Core	124.9	40.4	11.84	As Laid	As Laid	None	.....	.....	73 Percent Sand 27 Percent Pea Gravel by Weight	3.22	5.68	3.91	108	105	1:10	6.82	187.6	111.9	169,340	903	1512	7.32	14.7
7a	Cinder Tile	4 in. x 8 in. x 16 in. 3-Core Partition	99.9	33.9	4.17	As Laid	As Laid	None	.....	.....	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	7.72	66.3	43.8	55,600	838	1268	11.95	19.1
8a	Cinder Tile	4 in. x 8 in. x 16 in. 3-Core Partition	99.9	33.9	9.33	As Laid	As Laid	1 in. Air Space between Partition Tile	.....	.....	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	7.72	66.3	43.8	55,600	838	1268	11.95	19.1
8b	Cinder Tile	4 in. x 8 in. x 16 in. 3-Core Partition	99.9	33.9	9.33	As Laid	As Laid	1 in. Rock Wool between Partition Tile	9.97	0.830	100 Percent Cinders ½ in. to 0	4.11	.....	4.11	65	.....	1:8	7.72	66.3	43.8	55,600	838	1268	11.95	19.1

Table 2—Monolithic Walls, Description and Data

Wall No.	Type of Aggregate	Description of Wall	Density of Concrete in Wall lb/cu ft	Overall Thickness of Wall in Inches	Inside Surface Finish	Outside Surface Finish	Additional Insulation	Density of Insulating Material lb/cu ft	Weight of Insulation per Sq Ft of Wall Area	Aggregate Used in Wall Per Cent By Weight	Fineness Modulus of Aggregate			Dry Rodded Weight of Aggregate lb per cu ft		Mix Proportion Dry Rodded Volume	Water Cement Ratio W/C Gal per Sack	Average Slump Inches	28 Day Compressive Strength Wet			Percent Absorbtion at 28 Days	
											Fine	Coarse	Combined	Fine	Coarse				Area of Cylinder Sq In	Total Breaking Load Lb	Breaking Load in Lb/Sq In	By Wgt	By Vol
30a	Sand and Limestone	Sand and Limestone Plastic Mix	140.3	4.32	As Cast	As Cast	None	.....	.....	39.3 Percent Sand 60.7 Percent Crushed Limestone	3.00	6.80	5.33	109.9	97.53	1:2¼:4	8.0	5.50	28.84	111,253	3,853	6.02	13.51
31a	Sand and Gravel	Sand and Coarse Gravel—Plastic Mix	143.3	4.19	As Cast	As Cast	None	.....	.....	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	107.6	1:2¼:4	8.0	5.90	28.59	107,867	3,772	5.24	12.03
32a	Sand and Gravel	Sand and Coarse Gravel—Dry Tamp Mix	148.8	4.05	As Cast	As Cast	None	.....	.....	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	107.6	1:2¼:4	6.0	0.50	28.25	152,173	5,385	4.17	9.95
33a	Cinder	Cinder Aggregate Plastic Mix	94.4	3.90	As Cast	As Cast	None	.....	.....	100 Percent Cinders 39.8 Percent Fine 60.2 Percent Coarse	3.25	6.77	5.37	65.5	55.64	1:2¼:4	11.2	3.94	28.06	28,312	1,009	16.55	24.98
34a	Haydite	Haydite Aggregate Plastic Mix	77.7	3.96	As Cast	As Cast	None	.....	.....	100 Percent Haydite 42.6 Percent Fine 57.4 Percent Coarse	2.76	6.67	5.00	58.6	44.41	1:2¼:4	10.5	4.87	28.8	64,992	2,252	23.07	28.80
35a	Sand and Gravel	Two Sand and Gravel Slabs—Dry Tamped 2½ in. Air Space	148.25	10.66	As Cast	As Cast	2.52 in. Air Space	.....	.....	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	107.6	1:2¼:4	6.0	0.30	28.21	133,366	4,728	4.34	10.31
35b	Sand and Gravel	Two Sand and Gravel Slabs—Dry Tamped 2½ in. Air Space	148.25	10.66	As Cast	As Cast	2.52 in. Dry Cinders	75.4	15.87	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	107.6	1:2¼:4	6.0	0.30	28.21	133,366	4,728	4.34	10.31
35c	Sand and Gravel	Two Sand and Gravel Slabs—Dry Tamped 2½ in. Air Space	148.25	10.66	As Cast	As Cast	2.52 in. Rock Wool	14.3	2.99	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	107.6	1:2¼:4	6.0	0.30	28.21	133,366	4,728	4.34	10.31
36a	Cinder	Sand and Coarse Cinders—Dry Tamped	118.7	3.96	As Cast	As Cast	None	.....	.....	52.6 Percent Sand 47.4 Percent Cinders	3.00	6.77	5.21	109.9	55.64	1:2¼:4	6.75	0.30	28.2	90,850	3,218	8.35	15.67
37a	Sand and Gravel	Sand and Gravel Plastic Mix 2 in. Slab with 4 in. x 4 in. Ribs 24 in. O.C.	143.2	2.18	As Cast	As Cast	None	.....	.....	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	106.5	1:2¼:4	8.68	7.49	28.57	78,657	2,857	6.15	14.42

Table 2—Monolithic Walls, Description and Data

Wall No.	Type of Aggregate	Description of Wall	Density of Concrete in Wall Lb/cu ft	Overall Thickness of Wall in Inches	Inside Surface Finish	Outside Surface Finish	Additional Insulation	Density of Insulating Material Lb/cu ft	Weight of Insulation per Sq Ft of Wall Area	Aggregate Used in Wall Per Cent By Weight	Fineness Modulus of Aggregate: Fine	Fineness Modulus of Aggregate: Coarse	Fineness Modulus of Aggregate: Combined	Dry Rodded Weight of Aggregate Lb per cu ft: Fine	Dry Rodded Weight of Aggregate Lb per cu ft: Coarse	Mix Proportion Dry Rodded Volume	Water Cement Ratio W/C Gal per Sack	Average Slump Inches	28 Day Compressive Strength Wet: Area of Cylinder Sq In	28 Day Compressive Strength Wet: Total Breaking Load Lb	28 Day Compressive Strength Wet: Breaking Load in Lb/Sq In	Percent Absorption at 28 Days: By Wgt	Percent Absorption at 28 Days: By Vol
37b	Sand and Gravel	Sand and Gravel Plastic Mix 2 in. Slab with 4 in. x 4 in. Ribs 24 in.O.C. 5 in. Air Space	143.2	7.68	½ in. Plaster on Metal Lath Furred 1 in. on Ribs	As Cast	5 in. Air Space	.....	.....	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	106.5	1:2¼:4	8.68	7.49	28.57	78,657	2,857	6.15	14.42
37c	Sand and Gravel	Sand and Gravel Plastic Mix 2 in. Slab with 4 in. x 4 in. Ribs 24 in.O.C. 5 in. Rock Wool	143.2	7.68	½ in. Plaster on Metal Lath Furred 1 in. on Ribs	As Cast	5 in. Rock Wool	9.53	3.63	36.5 Percent Sand 63.5 Percent Gravel	3.00	6.71	5.36	109.9	106.5	1:2¼:4	8.68	7.49	28.57	78,657	2,857	6.15	14.42

the surface of the wall in a layer of uniform thickness, all heat must presumably pass through the material and it may be considered as an effective application. If the insulating material is placed in such manner as not to obstruct all paths for the flow of heat its effectiveness may be reduced. In this investigation insulating materials have been used in the cells or cores of the concrete blocks and also as a uniform sheet parallel to the surfaces of the walls.

Method of Procedure

In all cases the aggregate was selected and graded as per specifications. In each case a sieve analysis was made and the different aggregates were mixed in the required proportion to give the proper fineness modulus. Preliminary tests were made to determine the proper water to cement ratio to give the required slump and strength characteristics. The blocks for the masonry walls were constructed in a standard block machine at the Crown Sidewalk and Block Co.'s plant, Minneapolis, Minn. These were steam cured for 24 hours and then exposed to the air for the remainder of the curing period. After being thoroughly cured and dried out they were built into test walls 5½ ft square with standard ⅜ in. mortar joints between the blocks. In constructing the walls the mortar was buttered on the edges but not on the cross partitions between the air cells, thus following recommended and standard construction practice for walls of this type. After a sufficient curing period to thoroughly dry out the mortar between the joints the walls were tested by the standard hot box method.

For the monolithic walls the aggregates were selected and graded in the same manner as for the concrete blocks and the walls were constructed in the laboratory according to specifications. At the time of building the walls 6 in. x 12 in. cylinders were cast which were later tested to give the strength of the concrete. After the walls were thoroughly cured and dried out they were tested by the standard hot box method to determine their thermal conductivity.

Description of Walls Tested

The complete physical data covering walls tested are shown in Tables 1 and 2 for masonry and monolithic walls, respectively. The cinders used in this construction were obtained from the Northern States Power Riverside Plant, Minneapolis, Minn.

The construction data for the walls are shown in Tables 3 and 4, for the masonry and monolithic walls, respectively. Figs. 1, 2 and 3 show the detailed dimensions of the different blocks used. The mortar used in building the masonry walls consisted of one part cement to three parts plaster sand, and to this mixture was added 10 per cent lime.

Walls No. 8a and 8b were built up of two 4-in. cinder tile walls with tie rods and separated by a 1-in. air space. The tie rods were made of 28-gage galvanized iron about ¾ in. wide and of sufficient length so that they extended approximately 3 in. in each wall and across the air space. They were placed on top of each course of tile 12 in. on center horizontally and grouted in place with mortar.

Walls No. 35a, 35b, and 35c were made of two 4-in.

sand and gravel dry tamp monolithic walls spaced 2½ in. apart by means of tie rods. The tie rods were ¼ in. in diameter and extended about 3 in. in each wall. They were spaced 12 in. on centers horizontally and 9 in. on centers vertically in the test section.

Test Results

The complete thermal conductivity data for the walls, obtained by the hot box method, are given in Tables 5 and 6. These tables also include some of the physical characteristics of the walls taken from Tables 1 and 2 in order to more easily identify the wall construction when referring to the thermal properties.

In taking test data there was some difficulty in getting consistent surface temperatures from which to calculate surface conductance coefficients. This was due to the fact that the surfaces of several of the walls were somewhat rough, making it impossible to get precision measurements of surface temperatures, and also because many

Table 3—Construction Data for Masonry Walls

Wall No.	Type of Aggregate in Blocks	Aggregate Grading and Average Fineness Modulus	Blocks Manufactured Date	Walls Built Date	Inside Surface Treatment	Date of Treatment	Outside Surface Treatment	Date of Treatment
1a	Cinders		11-23-34	1-3-35	None		None	
1b	Cinders		11-23-34	1-3-35	None		2 Coats Water Proofed White Portland Cement Paint	3-13-35
1c	Cinders		11-23-34	1-3-35	None		2 Coats Water Proofed White Portland Cement Paint	3-13-35
1d	Cinders	Average Fineness Modulus=4.11 Percent Passing ½ in.—100.0 No. 16— 32.9 ⅜ in.— 94.4 No. 30— 21.6 No. 4— 71.7 No. 50— 12.9 No. 8— 49.3 No. 100— 6.1	11-23-34	1-3-35	None		2 Coats Water Proofed White Portland Cement Paint	3-13-35
1e	Cinders		11-23-34	1-3-35	None		2 Coats Water Proofed White Portland Cement Paint	3-13-35
1f	Cinders		11-23-34	1-3-35	½ in. Plaster on Metal Lath Furred 1 in.	4-9-35	2 Coats Water Proofed White Portland Cement Paint	3-13-35
1g	Cinders		11-23-34	1-3-35	½ in. Plaster applied direct	5-2-35 5-4-35	None	
1h	Cinders		11-23-34	1-3-35	½ in. Insulation Board Furred 1 in. strips 16 in. on center	5-9-35	½ in. Plaster Applied Direct	5-2-35 5-4-35
2a	Haydite	Average Fineness Modulus=3.92 Percent Passing ½ in.—100.0 No. 16— 38.2 ⅜ in.— 93.1 No. 30— 21.9 No. 4— 68.5 No. 50— 14.4 No. 8— 61.7 No. 100— 10.0	11-23-34	1-3-35	None		None	
2b	Haydite		11-23-34	1-3-35	None		2 Coats Water Proofed White Portland Cement Paint	3-16-35
3a	Sand and Gravel	Average Fineness Modulus=3.91 Percent Passing ⅜ in.—100.0 No. 16— 41.1 No. 4— 79.4 No. 30— 22.0 No. 8— 59.5 No. 50— 5.7 No. 100— 1.3	11-14-34	1-3-35	None		None	
3b	Sand and Gravel		11-14-34	1-3-35	None		2 Coats Water Proofed White Portland Cement Paint	3-9-35
4a	Limestone	Average Fineness Modulus=4.0 Percent Passing ⅜ in.—100.0 No. 50— 14.6 No. 4— 73.7 No. 100— 9.1 No. 16— 32.3	11-14-34	1-2-35	None		None	
5a	Cinders	Average Fineness Modulus=4.05 Percent Passing ½ in.—100.0 No. 16— 36.8 ⅜ in.— 90.4 No. 50— 18.2 No. 4— 65.1 No. 100— 9.5	11-6-35	1-2-35	None		None	
6a	Sand and Gravel	Average Fineness Modulus=3.91 Percent Passing ⅜ in.—100.0 No. 16— 41.1 No. 4— 79.4 No. 30— 22.0 No. 8— 59.5 No. 50— 5.7 No. 100— 1.3	11-6-35	1-2-35	None		None	
7a	Cinders	Average Fineness Modulus=4.11 Percent Passing ½ in.—100.0 No. 16— 32.9 ⅜ in.— 94.4 No. 30— 21.6 No. 4— 71.7 No. 50— 12.9 No. 8— 49.3 No. 100— 6.1	11-24-35	1-4-35	None		None	
8a	Cinders		11-24-35	1-4-35	None		None	
8b	Cinders		11-24-35	1-4-35	None		None	

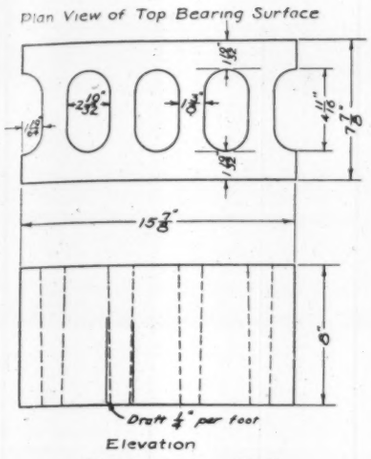


Fig. 1—3 core block 8 in. x 8 in. x 16 in.

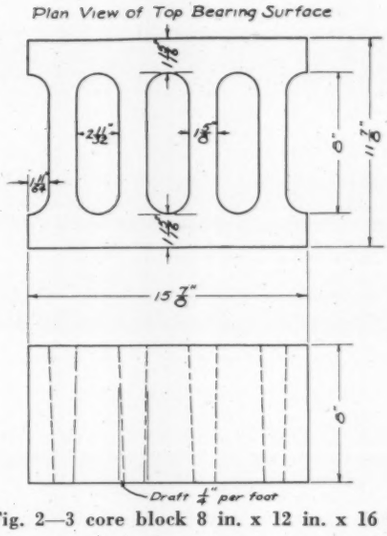


Fig. 2—3 core block 8 in. x 12 in. x 16 in.

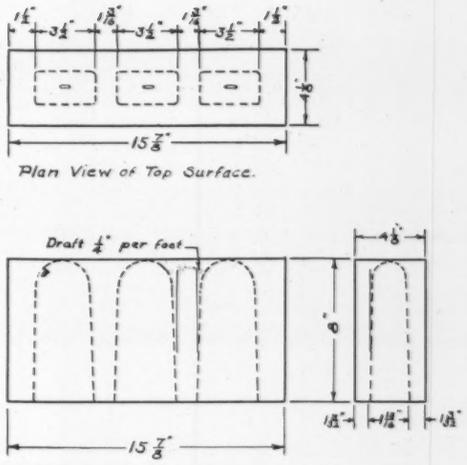


Fig. 3—3 partition core 4 in. x 8 in. x 16 in.

Table 4—Construction Data for Monolithic Walls

Wall No.	Type of Aggregate in Wall	Grading of Aggregate and Average Fineness Modulus	Mix Proportions by Volume and Kind of Mix	Number of Lifts Required for Pouring Wall	Date of Building Wall
30a	Sand and Limestone Concrete	Average Fineness Modulus=5.33 Percent Passing Fine: 3/8 in.—100.0; No. 4—99.6; No. 8—88.8; No. 16—64.1; No. 30—36.1; No. 50—9.2; No. 100—1.8 Coarse: 1 in.—100.0; 3/4 in.—79.8; 1/2 in.—64.6; 3/8 in.—37.4; No. 4—3.0; No. 8—0.0	1:2¼:4 Plastic Mix	4	12-19-34
31a	Sand and Coarse Gravel Concrete	Average Fineness Modulus=5.36 Percent Passing Fine: 3/8 in.—100.0; No. 4—99.6; No. 8—88.8; No. 16—64.1; No. 30—36.1; No. 50—9.2; No. 100—1.8 Coarse: 1 in.—100.0; 3/4 in.—84.9; 1/2 in.—65.9; 3/8 in.—41.1; No. 4—3.2; No. 8—0.0	1:2¼:4 Plastic Mix	4	12-27-34
32a	Sand and Coarse Gravel Concrete		1:2¼:4 Dry Tamp Mix	7	1-8-35 1-9-35
33a	Cinder Concrete	Average Fineness Modulus=5.37 Percent Passing Fine: No. 4—99.9; No. 8—73.2; No. 16—51.5; No. 30—33.5; No. 50—13.7; No. 100—3.7 Coarse: 1 in.—100.0; 3/4 in.—82.7; 1/2 in.—64.7; 3/8 in.—35.8; No. 4—4.5; No. 8—0.0	1:2¼:4 Plastic Mix	4	1-7-35
34a	Haydite Concrete	Average Fineness Modulus=5.00 Percent Passing Fine: No. 4—99.9; No. 8—94.8; No. 16—58.2; No. 30—33.3; No. 50—21.5; No. 100—14.7 Coarse: 3/4 in.—100.0; 1/2 in.—88.7; 3/8 in.—38.8; No. 4—5.3; No. 8—0.0	1:2¼:4 Plastic Mix	4	1-11-35
35a	Sand and Gravel Concrete	Average Fineness Modulus=5.36 Percent Passing Fine: 3/8 in.—100.0; No. 4—99.6; No. 8—88.8; No. 16—64.1; No. 30—36.1; No. 50—9.2; No. 100—1.8 Coarse: 1 in.—100.0; 3/4 in.—84.9; 1/2 in.—65.9; 3/8 in.—41.1; No. 4—3.2; No. 8—0.0	1:2¼:4 Dry Tamp Mix	7	1-18-35 1-19-35
35b	Sand and Gravel Concrete		1:2¼:4 Dry Tamp Mix	7	1-18-35 1-19-35
35c	Sand and Gravel Concrete		1:2¼:4 Dry Tamp Mix	7	1-18-35 1-19-35
36a	Sand and Coarse Cinder Concrete	Average Fineness Modulus=5.21 Percent Passing Fine: 3/8 in.—100.0; No. 4—99.6; No. 8—88.8; No. 16—64.1; No. 30—36.1; No. 50—9.2; No. 100—1.8 Coarse: 1 in.—100.0; 3/4 in.—82.7; 1/2 in.—64.7; 3/8 in.—35.8; No. 4—4.5; No. 8—0.0	1:2¼:4 Dry Tamp Mix	7	1-14-35
37a	Sand and Gravel Concrete	Average Fineness Modulus=5.36 Percent Passing Fine: 3/8 in.—100.0; No. 4—99.6; No. 8—88.8; No. 16—64.1; No. 30—36.1; No. 50—9.2; No. 100—1.8 Coarse: 3/4 in.—100.0; 1/2 in.—70.0; 3/8 in.—40.0; No. 4—0.0	1:2¼:4 Plastic Mix	7	1-28-35
37b	Sand and Gravel Concrete		1:2¼:4 Plastic Mix	7	1-28-35
37c	Sand and Gravel Concrete		1:2¼:4 Plastic Mix	7	1-28-35

of the walls contained irregular cored out spaces which gave different heat resistances at different sections of the wall. For example, the surface temperatures for a hollow concrete block wall would be different when taken at a point opposite an air space than when taken at a point opposite the partition between air spaces. In some of the ribbed wall construction as much as 5 deg was noted between those points over the ribs as compared to those over the air spaces. In such cases it would be impossible to get any consistent surface coefficient without taking the average of a large number of surface temperatures. Since the over-all transmission coefficients were calculated on the basis of the differences in air temperatures between the two sides they were not affected by the irregularities in surface temperatures and were, therefore, taken as a basis for computing the results and making

Table 5—Test Data and Results for Masonry Walls

Wall No.	Test No.	Date of Test	Description of Wall	Inside Surface Finish	Outside Surface Finish	Additional Insulation in Walls	Air Temperatures F			Coefficient of Heat Transmission		
							High Side	Low Side	Mean Temp.	*C*	*U*	*U* Corrected to 15 mph Wind Vel.
1a		2-12-35	8 in. x 8 in. x 16 in. 3-Oval Core Cinder Block	As laid	As laid	None	80.81	—0.78	40.01	0.583	0.335	0.399
1a	2	3-7-35		As laid	As laid	None	80.07	0.13	40.10	0.577	0.333	0.396
1a	9	3-12-35		As laid	As laid	None	79.98	0.18	40.08	0.577	0.333	0.396
1b	10 15	3-26-35		As laid	Two Coats Water Proofed White Portland Cement Paint	None	79.56	0.48	40.02	0.522	0.314	0.370
1c	18	4-2-35		As laid	Two Coats Water Proofed White Portland Cement Paint	Cores filled with granulated cork	80.38	—0.43	39.98	0.238	0.189	0.261
1d	17	3-30-35		As laid	Two Coats Water Proofed White Portland Cement Paint	Cores filled with dry cinders	80.23	—0.27	39.98	0.364	0.249	0.283
1e	19	4-4-35		As laid	Two Coats Water Proofed White Portland Cement Paint	Cores filled with Rock Wool	80.43	—0.41	40.01	0.254	0.192	0.211
1f	28	4-26-35		½ in. Plaster on metal lath furred 1 in.	Two Coats Water Proofed White Portland Cement Paint	Cores filled with Rock Wool	80.23	—0.32	39.96	0.198	0.158	0.171
1g	37	5-28-35		½ in. plaster applied direct	As laid	Cores filled with Rock Wool	80.54	—0.67	39.94	0.251	0.190	0.209
1h	36	5-26-35		½ in. insulation board Furred 1 in. Strips 16 in. on centers	½ in. plaster applied direct	Cores filled with Rock Wool	80.64	—0.64	40.00	0.164	0.136	0.147
2a	3	2-14-35	8 in. x 8 in. x 16 in. 3-Oval Core Haydite Block	As laid	As laid	None	80.07	0.0	40.03	0.498	0.305	0.357
2a	11	3-15-35		As laid	As laid	None	79.80	0.20	40.00	0.493	0.303	0.354
2b	16	3-28-35		As laid	Two Coats Water Proofed White Portland Cement Paint	None	80.23	—0.27	39.98	0.454	0.289	0.334
3a	1	2-8-35	8 in. x 8 in. x 16 in. 3-Oval Core Sand and Gravel Block	As laid	As laid	None	80.15	0.29	40.22	0.914	0.423	0.530
3a	8	3-5-35		As laid	As laid	None	78.40	1.74	40.07	0.882	0.416	0.519
3b	13	3-22-35		As laid	Two Coats Water Proofed White Portland Cement Paint	None	79.68	0.40	40.04	0.851	0.409	0.509
4a	6	2-29-35	8 in. x 8 in. x 16 in. 3-Oval Core Limestone Block	As laid	As laid	None	78.92	0.94	39.93	0.856	0.410	0.510
5a	7	3-3-35	8 in. x 12 in. x 16 in. 3-Oval Core Cinder Block	As laid	As laid	None	79.31	0.64	39.98	0.531	0.318	0.374
6a	12	3-19-35	8 in. x 12 in. x 16 in. 3-Oval Core Sand and Gravel Block	As laid	As laid	None	79.94	0.10	40.02	0.777	0.391	0.481
7a	14	3-24-35	4 in. x 8 in. x 16 in. 3-Core Cinder Partition Tile	As laid	As laid	None	80.51	—0.52	40.00	1.003	0.441	0.559
8a	4	2-22-35	Double 4 in. x 8 in. x 16 in. Cinder Partition Tile Spaced 1 in. Apart	As laid	As laid	1 in. Air Space	79.62	0.34	39.98	0.358	0.247	0.279
8b	5	2-27-35	Double 4 in. x 8 in. x 16 in. Cinder Tile Partition spaced 1in. Apart	As laid	As laid	1 in. Rock Wool in Space Between Partition Tile	79.82	0.15	39.99	0.204	0.162	0.176

Table 6—Test Data and Results for Monolithic Walls

Wall No.	Test No.	Date of Test	Description of Wall	Inside Surface Finish	Outside Surface Finish	Insulation	Air Temperature F			Coefficient of Heat Transmission		
							High Side	Low Side	Mean Temp.	*C*	*U*	*U* Corrected to 15 mph Wind Vel.
30a	20	4–6–35	4 in. Sand and Limestone Concrete Plastic Mix	As Cast	As Cast	None	79.49	0.53	40.01	2.810	0.615	0.871
31a	21	4–9–35	4 in. Sand and Coarse Gravel Concrete Plastic Mix	As Cast	As Cast	None	80.61	—0.61	40.00	2.976	0.622	0.886
31a	33	5–14–35	4 in. Sand and Coarse Gravel Concrete Plastic Mix	As Cast	As Cast	None	79.38	0.71	40.04	2.918	0.620	0.882
32a	24	4–16–35	4 in. Sand and Coarse Gravel Concrete Dry Tamp Mix	As Cast	As Cast	None	79.76	0.15	39.96	3.230	0.632	0.906
33a	22	4–11–35	4 in. Cinder Concrete Plastic Mix	As Cast	As Cast	None	79.98	—0.39	39.80	1.489	0.515	0.682
33a	23	4–13–35	4 in. Cinder Concrete Plastic Mix	As Cast	As Cast	None	79.98	0.16	40.07	1.456	0.511	0.676
34a	25	4–18–35	4 in. Haydite Concrete Plastic Mix	As Cast	As Cast	None	80.21	—0.22	40.00	0.943	0.429	0.540
35a	27	4–24–35	Double 4 in. Sand and Gravel Concrete Dry Tamp Mix	As Cast	As Cast	2.52 in. Air Space	80.13	—0.29	39.92	0.660	0.359	0.433
35b	29	5–3–35	Double 4 in. Sand and Gravel Concrete Dry Tamp Mix	As Cast	As Cast	2.52 in. Dry Cinders	80.27	—0.43	39.92	0.509	0.320	0.378
35c	34	5–17–35	Double 4 in. Sand and Gravel Concrete Dry Tamp Mix	As Cast	As Cast	2.52 in. Rock Wool	80.71	—0.78	39.97	0.170	0.140	0.150
36a	26	4–20–35	4 in. Sand and Coarse Cinder Concrete Dry Tamp Mix	As Cast	As Cast	None	80.20	—0.12	40.04	2.160	0.577	0.797
37a	35	5–21–35	2 in. Sand and Gravel Concrete with 4 in. x 4 in. Ribs, Plastic Mix	As Cast	As Cast	None	79.47	0.63	40.05	5.710	0.691	1.032
37b	32	5–10–35	2 in. Sand and Gravel Concrete with 4 in. x 4 in. Ribs, Plastic Mix	½ in. Plaster on metal lath furred 1 in. on Ribs	As Cast	5 in. Air Space	80.07	—0.18	39.95	0.687	0.367	0.445
37c	30	5–6–35	2 in. Sand and Gravel Concrete with 4 in. x 4 in. Ribs, Plastic Mix	½ in. Plaster on metal lath furred 1 in. on Ribs	As Cast	5 in. Rock Wool	80.86	—0.90	39.98	0.143	0.121	0.128
37c	31	5–8–35	2 in. Sand and Gravel Concrete with 4 in. x 4 in. Ribs, Plastic Mix	½ in. Plaster on metal lath furred on 1 in. Ribs	As Cast	5 in. Rock Wool	79.80	0.42	40.11	0.143	0.121	0.128

comparisons between the various types of walls. In order to take care of the irregularities in surface temperatures as mentioned, and the resulting differences in surface coefficients, averages were taken of all of the outside surface coefficients and all of the inside surface coefficients and these averages were taken as the true value for each test. From these coefficients the surface temperatures were corrected. The average of all outside surface coefficients was 1.55 and of all the inside coefficients 1.6

Table 7 shows thermal conductivity values for the different types of concrete used in the monolithic walls.

Wall No. 35a (not shown in the Table) is a sand and gravel dry tamp mix consisting of two 4-in. monolithic slabs with a 2½-in. air space between. It is of the same material and construction as 32a shown in the Table. Assuming an air space conductance of 1.1, the calculated conductivity value of the concrete is found to be 13. This checks with the conductivity of wall 32a which gave a test value of $k = 13.1$.

Wall 31a is of the same material as 32a, the difference being that it was made up into a plastic mix while 32a was a dry tamp mix. The thermal conductivity of 31a was 12.4 as compared with 13.1 for 32a. By referring to Table 2 it will be noted that wall 31a has an absorption of 12.03 per cent as compared with 9.95 per cent for 32a, and a breaking load of 3772 as compared with 5385 for 32a. These values indicate that 31a is slightly more porous than 32a, which probably accounts for the slightly lower conductivity. Walls 30a and 31a have substantially the same conductivity and as shown in Table 2 their breaking loads and percentages of water absorption are about equal. From these tests a conductivity of from 12 to 13 for the average sand and gravel or limestone concrete appears to be reasonable.

From the test results a relation is suggested between thermal conductivity and percentage of water absorption

Table 7—Effects of Aggregate on Conductivity for Monolithic Walls

Wall No.	Description	Conductance *C*	Thickness Inches	Thermal Conductivity *k*
30a	4 in. sand and limestone concrete Plastic Mix	2.810	4.318	12.14
31a	4 in. sand and coarse gravel concrete Plastic Mix	2.976	4.168	12.40
32a	4 in. sand and coarse gravel concrete Dry Tamp Mix	3.230	4.050	13.10
33a	4 in. 100 per cent cinder concrete Plastic Mix	1.472	3.902	5.75
34a	4 in. 100 per cent Haydite Plastic Mix	0.943	3.960	3.73
36a	4 in. sand and coarse cinder Dry Tamp Mix	2.160	3.958	8.54

Table 8—Effect of Aggregate on Conductivity for Masonry Walls

Wall No.	Description of Blocks Used	Conductance C
1a	8 in. x 8 in. x 16 in.—3-Oval Core Cinder Block	0.577
2a	8 in. x 8 in. x 16 in.—3-Oval Core Haydite Block	0.495
3a	8 in. x 8 in. x 16 in.—3-Oval Core Sand and Gravel Block	0.882
4a	8 in. x 8 in. x 16 in.—3-Oval Core Limestone Block	0.856
5a	8 in. x 8 in. x 16 in.—3-Oval Core Cinder Block	0.531
6a	8 in. x 12 in. x 16 in.—3-Oval Core Sand and Gravel Block	0.777

for monolithic concrete. The curve of Fig. 4 shows this relation, based on the tests now available, and while the investigation should be extended to more thoroughly cover the different aggregates before attempting to draw definite conclusions, the relation appears to be sufficiently close for many practical purposes. The percentage by volume of water absorption indicates the porosity of the concrete, which is one of the governing factors for conductivity.

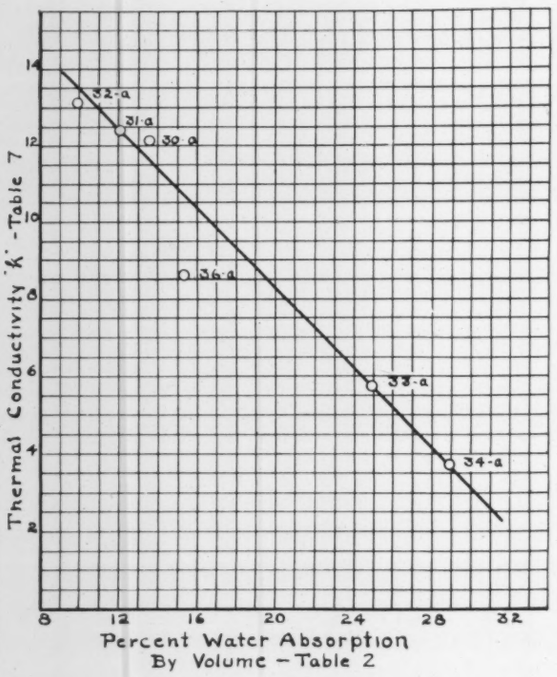


Fig. 4—Curve showing relation between thermal conductivity and water absorption for monolithic concrete

From the results shown in Tables 7 and 8 the reduction in thermal conductivity for the 8-in. monolithic wall when using cinders, as compared with that for sand and gravel, is

$$\frac{13.1 - 5.75}{13.1} \times 100 = 56.1 \text{ per cent,}$$

and for masonry walls it is,

$$\frac{0.882 - 0.577}{0.882} \times 100 = 34.6 \text{ per cent.}$$

When using Haydite as an aggregate the reduction in thermal conductivity, as compared with sand and gravel, is

$$\frac{13.1 - 3.73}{13.1} \times 100 = 71.5 \text{ per cent for monolithic walls, and}$$

$$\frac{0.882 - 0.495}{0.882} \times 100 = 43.9 \text{ per cent for masonry walls.}$$

The ratio of the reduction for monolithic, as compared to masonry walls, is $\frac{56.1}{34.6}$ or 1.62 when using cinders, and $\frac{71.5}{43.9}$ or 1.63 when using Haydite.

The reason that the reduction is 62 per cent greater for the monolithic walls than for the block walls is due to the fact that a part of the heat passes directly through the air spaces in the masonry walls and is not affected by the kind of aggregate used.

There are no 12-in. monolithic walls for comparison, but the 12-in. masonry walls, 5a and 6a of Table 8 show a reduction in conductance of $\frac{0.777 - 0.531}{0.777} \times 100 = 31.7$ per cent when using cinders as compared with sand and gravel, whereas for the 8-in. wall the reduction was 34.6 per cent. This rather close agreement between the 8-in. and the 12-in. walls merely shows that the core spaces have about the same relative effectiveness in both types of blocks.

The relative insulating values of the 8-in. and 12-in. masonry walls are shown by comparing the test results for 1a to 5a and 3a to 6a. Taking 1a and 5a the reduction in conductance is,

$$\frac{0.577 - 0.531}{0.577} \times 100 = 8.29 \text{ per cent.}$$

Taking 3a and 6a the reduction is,

$$\frac{0.882 - 0.777}{0.882} \times 100 = 13.5 \text{ per cent.}$$

In the case of the monolithic walls the reduction in conductivity for a 12-in. wall over that for an 8-in. wall should be 50 per cent. The reason for this poor showing for the 12-in. masonry wall as compared with the 8-in. masonry wall is due to the fact that the size and shape of the air spaces are constructed to give substantially the same value for both walls. This is apparent by comparing the dimensions and air space construction of the 8-in. and 12-in. blocks as shown in Figs. 1 and 2. The air spaces in the 12-in. block are wider along the path of heat flow than those in the 8-in. block, but they are of no

Table 9—Insulating Value of Air Spaces Bounded by Two Parallel Concrete Surfaces Normal to the Path of Heat Flow

Wall No.	Description of Wall	Conductance C for Wall	Apparent Conductance a for Air Space
32a	Monolithic 4 in. sand and coarse gravel. Dry Tamp Mix	3.23	.....
35a	Two monolithic 4 in. sand and gravel. Dry Tamp Mix. Walls separated by 2.52 in. air space	0.660	1.11
7a	4 in. x 8 in. x 16 in.—3-Core Cinder Partition Tile	1.003	.....
8a	Two walls same as 7a spaced 1 in. apart.	0.358	1.25

greater insulating value as an air space reaches its maximum heat resistance at approximately 1 in. in width.

The results of Table 10 show the improvement in thermal conductivity obtained by placing insulation in the vertical air spaces of the test walls, and also some of the precautions which must be taken when insulating walls of this type. The percentage in improvement was based on the reduction in over-all conductivity coefficients for a 15-mile wind. The apparent conductivity value of 0.33 for Rock Wool as found when comparing masonry walls 8a and 9b is slightly higher than would be anticipated, but the value of 0.478 as calculated from the test results of walls 35a and 35c is so far out of line as to require further consideration.

In all cases the test walls consisted of two vertical sections spaced 2½ in. apart and held together with tie rods which passed through the air space or insulating material. These tie rods were embedded in the concrete at both ends and provided paths of high heat conductivity. If it is assumed that the contact between the ends of the rods and the concrete was of sufficient area to supply heat to the rods at one end and remove it from the other in the same proportion as it was supplied and taken away from the air space or the insulating material in the air space, then the insulating material and the rods would each transmit a part of the total heat, which would be proportional to their heat conducting capacity. In each case this capacity would be equal to the area of the material times its thermal conductivity. If the conductivity of Rock Wool is taken as 0.27 and that of iron at 324.0, one square foot of tie rod is equal to 324.0 ÷ 0.27 or 1200 sq ft of Rock Wool as a heat conductor.

In wall 8b there were 15 tie strips of 28-gage metal ¾-in. wide, giving a total area of 0.146 sq in., or the equivalent of,

$$\frac{0.146}{144} \times 1200 = 1.22 \text{ sq ft of Rock Wool.}$$

Correcting the calculated value of 0.33 gives

$$0.33 \times \frac{9 \text{ (square feet of test area)}}{9 + 1.22 \text{ (equivalent area of insulation)}} = 0.291$$

as the true thermal conductivity value for Rock Wool used in the masonry walls.

For wall 35c there were twelve ¼-in. tie rods through the test area equal to 0.588 sq in. in area, or the equivalent of

$$\frac{0.588}{144} \times 1200 = 4.9 \text{ sq ft of insulation.}$$

Correcting the calculated value of 0.478 gives

$$0.478 \times \frac{9}{9 + 4.9} = 0.31$$

as the true value of k for Rock Wool when using it in the monolithic wall.

While the assumptions as to the proportional amounts of heat conducted through the tie rods and the insulating materials are only approximately correct, the calculations based on them give reasonable values for the conductivity coefficient of the insulating material, and by this assumption calculated over-all coefficients agree reasonably well with test coefficients.

If metal tie rods, having their ends embedded in a high conductivity material, pass through an insulated area, they become important factors in the heat conductivity through that area and must be taken into consideration in making calculations. The effect of such rods becomes more important as the thermal conductivity of the space is reduced. For best results the area of the rods should be kept as low as consistent with structural requirements, and it is probable that a greater improvement in the over-all coefficient for the test walls might have been obtained by reducing the number and size of such tie rods to minimum requirements.

The results in Table 11 show the effectiveness of insulating material when placed in the cores of concrete masonry walls. The high effective conductivities are due

Table 10—Insulation Placed in Air Spaces Bounded by Parallel Surfaces

Wall No.	Description of Wall	Over-all Coeff. U 15 Mile Wind Velocity	Percent Improvement in Over-all Coeff. U Due to Insulation	Over-all Resistance $1/U$	Gain in Resistance Due to Insulation	Apparent Conductivity of Insulating Material After Correcting for Air Space
8a	Two Masonry walls built of 4 in. x 8 in. x 16 in. 3-core cinder partition tile spaced 1 in. apart	0.279	.....	3.58	.....	.....
8b	Same as 8a with air space filled with Rock Wool	0.176	36.9	5.68	2.10	0.33
35a	Two 4 in. monolithic sand and gravel. Dry Tamp Mix. Concrete walls spaced 2.52 in. apart	0.433	.....	2.31	.....	.....
35b	Wall No. 35a. Air space filled with dry cinders	0.378	12.7	2.65	0.34	2.00
35c	Wall No. 35a. Air space filled with Rock Wool	0.150	65.3	.....	4.02	0.478

Table 11—Insulation Placed in Cores of the Blocks Used in Masonry Walls

8 in. x 8 in. x 16 in. 3-Oval Core Cinder Blocks

Wall No.	Insulating Material	Density of Insulation lb/cu ft	Lb Insulation per sq ft Wall Area	Equivalent Thickness of Insulation Over Wall Surface	Over-all Coeff. U for 15 Miles Wind Velocity
1b	None	.....	.....	.....	0.370
1c	Granulated Cork	5.12	1.34	3.15	0.201
1d	Dry Cinders	69.7	18.29	3.15	0.283
1e	Rock Wool	14.21	3.72	3.15	0.211

	Over-all Resistance $1/U$	Percent Improvement in Overall Coeff. U for Wall Tested	Gain in Resistance Due to Insulation	Effective Conductivity k for Insulating Material
1b	2.70	.....	.....	....
1c	4.97	45.7	2.27	1.38
1d	3.53	23.5	0.83	3.80
1e	4.74	43.0	2.04	1.56

Table 12—The Effectiveness of Insulation When Placed Between 4 in. x 4 in. Vertical Concrete Ribs in a Wall

Wall No.	Construction	Over-all Coeff. U 15 Mile Wind Velocity	Percent Improvement in Over-all Coeff. U	Equivalent Thickness of Insulation Over Wall Area	Over-all Resistance $1/U$
37a	2 in. sand and gravel monolithic concrete with 4 in. x 4 in. ribs. Plastic Mix.	1.032	....	....	0.968
37b	Same as 37a with ½ in. plaster on metal lath. Furred 1 in. on ribs	0.445	56.8	....	2.247
37c	Same as 37b with air space filled with 5 in. Rock Wool. Density 9.53 lb	0.128	87.5	4.16	7.812

to the fact that large percentages of heat flow through the solid partitions of concrete between the cores which are not affected by the insulation.

The effect of placing insulating material between vertical concrete studs of concrete walls is shown in the results for walls 37a, 37b and 37c, Table 12. In this table the equivalent thickness of insulation over the wall area was calculated by multiplying the total thickness of 5 in. between the studs by 20/24 to get the average thickness over the wall.

The gain in heat resistance for wall 37b over wall 37a is $2.247 - 0.968 = 1.28$. A part of this gain is due to the air space and a part to the metal lath and plaster. The gain in resistance due to adding insulation in the air space is equal to $7.812 - 2.247 = 5.56$. In adding this insulation the value of the air space as such is lost. Therefore a proportional amount should be added to the gain of 5.56 in order to get the actual added resistance to be accredited to the Rock Wool as applied:

$$5.56 + \left[0.91 \times \frac{20}{24}\right] = 6.32,$$

the equivalent resistance of the Rock Wool over the full surface of the wall.

Since the equivalent thickness of insulation is 4.16 in. the effective conductivity, k, for the Rock Wool is $\frac{4.16}{6.32} = 0.658$. The explanation for the low effective insulating value for Rock Wool when used in this manner is the same as that for insulating material applied in the cores of concrete blocks. The heat which flows through the 4 in. x 4 in. ribs is not affected by the insulation. The flow is, however, restricted to a certain extent by the application of the 1 in. x 2 in. wood furring strips.

The effect of Cement Paint on the surface of masonry walls is shown in Table 13. The gain is probably largely due to the fact that it prevents the circulation of air through the porous material near the surface rather than to any insulating qualities of the paint proper.

Conclusions

1. For concrete of average aggregates without special consideration for low density, a conductivity value of 12.0 to 13.0 is reasonable.
2. Light weight aggregates are more effective in reducing the conductance of monolithic walls than they are in reducing the conductance of masonry walls with cored out sections in the blocks.
3. The thermal conductivity of monolithic concrete is in general directly proportional to its density. Since the density is largely governed by its porosity and porosity is measured by the amount of water absorbed, the percentage of water absorption by volume is suggested as a measure of the thermal conductivity of monolithic concrete construction. This relation should have further investigation.
4. The reduction in conductance of a masonry wall built with 12-in. blocks over that of a similar wall built with 8-in. blocks depends upon the density of the aggregate, but for average construction it is less than 15 per cent, whereas for a monolithic wall the reduction would be 50 per cent. This difference is due largely to the shape and location of the air spaces in the design of the blocks.
5. In concrete masonry or monolithic walls built up with parallel slabs for the purpose of obtaining an air space between or for the use of insulating material between the two slabs, special consideration must be given to the conductivity of any tie rod or support between the slab.
6. The effectiveness of an insulating material when placed in the cores of concrete blocks will depend upon the thermal conductivity of insulation, the thermal conductivity of the aggregate, and the design of the cored spaces in the block.
7. From conclusions 4 and 5 it follows that in order to get the full value of an insulating material when placed in any wall, it must be so placed as to effectively block off all paths of heat flow which may join the two surfaces of the wall.
8. A surface finish may serve to reduce the interchange of air through the surface and therefore reduce the thermal conductivity.

Acknowledgment

The authors wish to acknowledge the assistance of Mr. R. E. Copeland of the *Portland Cement Association* in selecting typical aggregates, types of construction, and in working out the program in general.

Table 13—Effect of Cement Paint on the Surface of Masonry Walls

Wall No.	Description of Wall	Surface Finish	Conductance C	Reduction in Conductance, Percent, Due to Addition of Surface Paint
1a	8 in. x 8 in. x 16 in. 3-oval core cinder block	None	0.577	....
1b	Same as 1a	Two coats Water Proofed White Portland Cement Paint	0.522	9.5
2a	8 in. x 8 in. x 16 in. 3-oval core Haydite block	None	0.495	....
2b	Same as 2a	Two coats Water Proofed White Portland Cement Paint	0.454	8.3
3a	8 in. x 8 in. x 16 in. 3—Oval core sand and gravel block	None	0.882	....
3b	Same as 3a	Two coats Water Proofed White Portland Cement Paint	0.851	3.5

Ventilation Requirements

By C. P. Yaglou* *(MEMBER)*, E. C. Riley† *(MEMBER)*, and D. I. Coggins† *(NON-MEMBER)*
Boston, Mass.

A progress report of research sponsored by the American Society of Heating and Ventilating Engineers in cooperation with School of Public Health, Harvard University

IN a previous paper[1] Lehmberg and his co-workers outlined a technic for studying ventilation requirements from the standpoint of body odors. Their work was purely fundamental, dealing largely with the development and evaluation of a suitable scale for judging intensity of body odors, and application of this scale to a laboratory experiment for studying the factors affecting odor intensity in a confined space.

The work to be described here is an elaboration of Lehmberg's preliminary experiments. The object was to study the general problem of ventilation odors under normal conditions, comparable to those in schoolrooms, offices, homes and the like with the possibility of establishing ventilation requirements for various groups of individuals, including grade school children and adults, under representative winter and summer conditions. Three methods of odor control were studied dealing with personal sanitation, ventilation, and air washing.

Principles of Olfaction

It is often stated in the literature, and rightly so, that the human nose when properly utilized affords a better criterion of the quality of air in occupied rooms than any of the known physical or chemical tests. Intelligent use of the sense of smell in ventilation requires a knowledge of its functions and limitations, a brief outline of which is given here.

The organs of smell are situated at the upper part of the nasal cavities, one in each cavity. The essential part of the organ is a delicate mucous membrane, the so-called olfactory epithelium, which covers the upper turbinal bone and adjacent portion of the septum (see Fig. 1), an area only about 250 sq mm.[2] The membrane is yellowish in color and is innervated by filaments from the olfactory nerve. These filaments, or olfactory hairs, are believed to be lipoid in character and they constitute the true receptive elements of the organs of smell. They are bathed in a mucous secretion from numerous olfactory glands in the epithelium. In addition to olfactory cells, there are free nerve endings in the olfactory epithelium sensitive to irritants such as ammonia or sulfuric acid, but these are believed to have little or nothing to do with true odors.

It is now generally recognized that the olfactory organs are normally stimulated by molecules of odorous substances in the inspired air diffusing to the olfactory membrane where they must enter into solution with the mucous coating of the membrane before arousing the sense of smell by chemical action on the olfactory hairs.

In ordinary respiration, the course of air passing through the nasal cavity does not extend up high enough to strike the olfactory membrane, but the odoriferous particles reach the membrane by diffusion which gradually changes the air in the olfactory cleft. Sniffing appears to be the most effective and quickest way for the full perception of odors, as it directs the air stream upwards toward the olfactory areas.

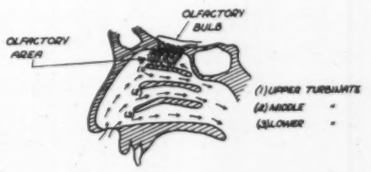


Fig. 1 — Section through right nasal cavity showing olfactory region and direction of air currents during inspiration

Man's sense of smell is normally aroused by inconceivably small concentrations of odoriferous substances. The sensitivity varies in different individuals. In a very recent review on odors and odor control, Pierce[3] reports that $\frac{1}{2{,}000{,}000}$ of a milligram of oil of rose per cubic centimeter of air can be distinctly smelled. Mercaptan, a liquid with a penetrating garlic odor, can be smelled in much smaller concentrations. The odor of butyric acid, a constituent of the body odor complex, can be detected in concentrations of 0.000009 miligrams per cubic centimeter of air.

The olfactory organs are quickly and easily fatigued if the exciting stimulus continues, although they can perceive the sudden appearance of new odors. The occupants of a crowded and poorly ventilated room are not capable of recognizing body odors which are very apparent or even intolerable to a newcomer. Breathing fresh air restores the sensitivity. Therefore, in order to get a good impression of ventilation conditions in a room, one should pass quickly from clean outdoor air

*Asst. Prof. of Industrial Hygiene, School of Public Health.
†Assistants, Dept. of Industrial Hygiene.
[1]Lehmberg, W. H., et al.: A Laboratory Study of Minimum Ventilation Requirements: Ventilation Box Experiments. A. S. H. V. E. Journal Section, *Heating, Piping and Air Conditioning*, January, 1935.
[2]Starling's Principles of Human Physiology. Lee and Febiger, Philadelphia, 1930.
For presentation at the 42nd annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Chicago, Ill., January, 1936.
[3]Pierce, W. MacL.: Odors and odor control. A thesis submitted to the Department of Industrial Hygiene, Harvard School of Public Health for the Degree of Master of Science, January, 1935.

to the room to be tested. One or two sniffs produce the strongest sensations of body odor, after which the sensation diminishes and soon ceases altogether.

Recovery of excitability is apparently likewise rapid, although it varies to some extent with the concentration and length of exposure to odorous air. In our experience with body odors, the breathing of fresh air for 5 to 10 min restores full excitability after exposure of 3 to 4 hours in crowded and poorly ventilated rooms.

For best results the nose must be neither too dry nor too moist. Persons with colds are unable to smell odors. It is possible by mixing odoriferous substances in certain proportions to annul or mask their effect on the olfactory organs. Likewise, in the presence of a strong odor, one cannot, as a rule, detect a weak odor simultaneously present in the air.

The unit of odor intensity is the olfactory threshold which itself is the smallest amount of an odorous substance required to stimulate the olfactory nerves. Different odors have different threshold values, and the threshold value of an odor expressed in grams per cubic centimeter is called an olfacty.

The intensity of odor perceived by the sense of smell does not vary in proportion to the concentration but approximately in proportion to the logarithm of the concentration. The variation is according to the law of physiological stimuli in general as expressed by the Weber-Fechner law,[4] namely, Sensation $\equiv K$ log. of stimulus-intensity.

Sources of Odors in Occupied Rooms

Odors in living rooms come mostly from the occupants themselves. Odors from furniture, etc., are not, as a rule, conspicuous in the presence of body odors, although they may be accentuated in a warm or moist atmosphere. The sources of body odors are numerous; foul breath, decaying teeth, sweat and sebacious secretions, especially when personal hygiene is deficient, gases from the stomach and bowels, and decomposition of matter from the skin and clothes are all contributory more or less, depending upon the socio-economic status of the occupants. Various gases, CH_4, CO_2, H, N, and H_2S have been detected[5] in intestinal gases eliminated from the rectum, and they may be tainted with the disagreeable odor of skatol and indol, which are normally present in the lower bowel.

Even healthy and clean persons freshly after a bath gave off in our experiments an appreciable amount of odor, which is apparently a normal waste product arising from metabolic processes and decomposition of matter in the skin and clothing.

Such odors are not, as a rule, known to be harmful, but they certainly induce a feeling of stuffiness and discomfort to anyone coming from outside. The occupants themselves may not be conscious of the odor but they seem to be capable of detecting stuffiness or lack of freshness in the air. Sensitive persons are occasionally affected in a pathological way by sitting in such rooms. The untoward effects of body odors on appetite for food and performance of physical work were studied extensively by Winslow and Palmer in the laboratories of the New York State Commission on Ventilation.[6]

Despite the opposing schools of thought concerning the health aspects of body odors, the general agreement is that they should be controlled preferably by personal habits of cleanliness, or by ventilation and air conditioning, as it is difficult to control the source of odor itself. According to the latest views the air of occupied rooms should give a favorable impression on entering, taking into consideration such factors as odors, freshness, temperature, humidity, drafts and other factors affecting the senses. The present paper is largely concerned with such primary, as well as secondary sense impressions, which were taken as a criterion of ventilation requirements.

Equipment

The experiments were carried out in two adjoining rooms, on the northwest side of the building. The rooms were approximately identical, having a floor area of 155 sq ft, a ceiling height of 9 ft 2½ in., a window area of 20 sq ft and a net air space of 1410 cu ft approximately. The windows were weatherstripped and all cracks carefully sealed with adhesive tape.

One of the rooms, hereafter referred to as the experimental room, was occupied by the subjects who constituted the source of odor production. The other room served as a control room for the judges who estimated the odor intensity in the experimental room.

A small tight door was cut in the common partition to allow direct passage of the judges from the control room to the experimental room in order to judge the odor intensity and air quality. Separate air conditioning units, installed in the corridor, kept the two rooms at approximately the same temperature and humidity in any given test, so that the only variable factors in the two rooms were the outdoor air supply and the number and type of occupants.

One of the air conditioners was equipped with a centrifugal humidifier capable of fully saturating the air passing through it under the experimental conditions. The other one was of the conventional spray-dehumidifier type. The rated capacity of both was 1000 cfm, but the orifices employed for measuring airflow reduced it to about 500 cfm, which was ample for the purpose of the experiments. The air was introduced to the rooms near the ceiling through 14 in. round ducts running along the entire length of the rooms and fitted with splitters. The ducts were perforated over half of the periphery with a multitude of holes ½ in. in diameter and 2½ in. on centers, facing toward the ceiling. The recirculated air was withdrawn at floor level through a 10 in. round duct. The exhaust air was allowed to escape to the corridor through sensitive check louvres attached near the bottom of the doors.

Accurate measurements of the total air supplied to the rooms, the amount recirculated, and that taken from out of doors, were made by means of thin-plate orifices designed in accordance with the *A. S. M. E.* standards[7] and checked against a calibrated venturi meter. Control

[4]Fair, G. M.: On the determination of odors and tastes in water. Journal *New Eng. Water Works Assn.*, vol. 47 (Sept., 1933).

[5]Collis, E. L., and Greenwood, Major: The health of the industrial worker. P. Blakiston's Son & Co., Philadelphia, 1921.

[6]Ventilation. Rept. N. Y. State Commission on Ventilation. E. P. Dutton & Co., New York, 1923.

[7]Fluid meters and their application. Rept. of Comm. on Fluid Meters, Research Publication, *Am. Soc. Mech. Engrs.*, 3rd ed., 1931.

of the air flow was by means of variable speed motors and different size orifices.

Dry and wet bulb temperatures were measured by means of aspirating psychrometers, and the air movement by means of kata-thermometers, or globe anemometers.[8] Measurements of carbon dioxide were made by means of a 20 cc modified Haldane gas analysis apparatus[9] for CO_2 only.

Experimental Procedure

Starting with a more or less definite plan, the procedure had to be modified during the first few experiments in order to allow for unforeseen conditions. During the preliminary part of the study, the outdoor air supply to the control room was fixed at the usual standard of 30 cfm per person with no recirculation. It was soon found out, however, when we began to study the influence of air space, that the odor strength in the control room was often higher than that in the experiment room. This upset the comparisons as it is physiologically impossible to judge odor strength by comparing an odor of standard intensity with one of lower intensity. The difficulty was overcome by increasing the outdoor air supply to 50 cfm per person and limiting the number of judges in the control room at any one time to 3, usually 2. This control standard was based on the minimum outdoor air supply required to keep the odor intensity in the control room approximately at the olfactory threshold, by comparison with clean outdoor air. The departure from the original plan is a happy one, as the olfactory threshold is a unit of odor intensity, and a much more rational base line than the arbitrary 30 cfm standard. The situation is analogous to our standards of sound or noise, in which the base line is likewise the threshold of hearing that is, a barely audible sound.

The experimental room was occupied by 3, 7, and 14 subjects in different series of experiments, so as to obtain 3 different floor areas per person, *i.e.*, 11, 22, and 52 sq ft and 3 different air spaces 100, 200 and 470 cu ft approximately. The air flow in the experimental room was varied from about 2 to 30 cfm per person in different experiments. In one series the total air supply remained constant at 30 cfm per person but the amount taken from out of doors was varied from 2 to 30 cfm. In another series only outdoor air was circulated through the experimental room. In a third series, the mixture of outdoor and recirculated air was washed, cooled, humidified or dehumidified in order to determine the effect of these processes on odor removal and on minimum ventilation requirements.

Keeping the air flow in the control room at 50 cfm per person in all experiments and the temperature and humidity approximately the same as that prevailing in the experimental room, the judges passed one at a time from the control to the experimental room, once every hour or so, recording the strength of body odor immediately after the change, according to the scale in Table 1. The agreement between judges was usually within $\pm$ ½ point on the scale, as in Lehmberg's work, once they have become familiar with the scale.

Altogether 60 men and women with more or less normal sense of smell served as judges. They were drawn from employees of the school and graduate students. Two of the judges devoted their whole time to the tests. The others usually from 8 to 15 in each test were called in when needed, and after a short stay in the control room, they passed to the experimental room to smell the air, and then released. All records were kept confidential by two men who ran the tests.

Table 1—Sensory Intensity Scale of Body Odor

Odor Intensity Index	Characteristic Term	Qualification
0	None	No perceptible odor.
½	Threshold	Very faint, barely detectable by trained judges; usually imperceptible to untrained persons.
1	Definite	Readily detectable by all normal persons but not objectionable.
2	Moderate	Neither pleasant nor disagreeable. Little or no objection. Allowable limit in rooms.
3	Strong	Objectionable. Air regarded with disfavor.
4	Very strong	Forcible, disagreeable.
5	Overpowering	Nauseating.

As a rule each test consumed a whole morning (9-12:30) or a whole afternoon (1:30-5:00). In a few instances the duration was shorter or longer. The equilibrium time with respect to odor intensity varied from one to three hours, inversely with the amount of outdoor air introduced.

Before and after each test the rooms were thoroughly ventilated in order to get rid of residual odors, and the air conditioning apparatus was kept clean at all times.

In order to secure uniformity in results and at the same time cover a fair cross-section of socio-economic status, the subjects were divided in 5 groups as follows:

(a) Sedentary men and women of average socio-economic status (between 16 and 60 years old), including high school, college and medical students, office workers, teachers, housewives, etc. (total 177).

(b) Grade school children between 7 and 14 years old of average or balanced socio-economic status (total 62).

(c) Laborers, such as janitors and street workers (total 8).

(d) School children of the poorest class (total 7).

(e) School children of the better class (total 28).

Most of the subjects belonged to groups *a* and *b*. They were apparently healthy and had normal personal habits. Variations from the normal were studied in a limited number of subjects classified under groups *c*, *d*, and *e*. Some of the children in groups *b*, *d*, and *e* were selected by the principal and nurse of a nearby school and sent to the tests with their teacher.

All subjects were paid adequately to keep them interested in the work. No attempt was made to control personal habits of hygiene or nutrition. However, the use of cosmetics, including face powder, had to be forbidden owing to a masking effect upon odors. Individual variations did occur, even among persons of apparently the same socio-economic status and with the same number of baths, but these were smoothed off by the use of a large number of subjects, as would be the case in most public buildings.

During the experiments the subjects were seated comfortably in arm chairs, and they read, wrote or played

[8] A new instrument to be described elsewhere.

[9] Haldane, J. S., and Graham, J. I.: Methods of air analysis. Charles Griffin & Co., Ltd., London, 1935.

cards. The clothing was of the customary indoor type according to the season.

The age, height, sex and occupation were recorded routinely in all tests. The date of last bath was also recorded more or less regularly, but this record was optional in the case of women. The weight was accurately determined before and after each test. At the beginning, near the middle and at the end of each test the adult subjects recorded their impressions of comfort, humidity, air quality and odor, according to a simple plan explained to them at the beginning of the test. The children answered questions pertaining to comfort only.

In this way information was obtained dealing with both primary and secondary impressions of air quality under various conditions of ventilation and with representative groups of persons. The primary impressions were those of the judges; the secondary, those of the subjects after becoming adapted to the conditions of the tests.

Results

The data presented in this progress report deal with more or less comfortable conditions of temperature and humidity in the winter and summer. Observations with high and low humidities and with temperatures near the upper and lower boundaries of the comfort zones are yet to be completed. In addition many other questions are now being studied, bearing on the subject matter and data under consideration, for presentation in a final paper.

Throughout this work during the past three years, advantage has been taken of the splendid opportunities offered for parallel *sideline* studies of problems dealing with seasonal variation of comfortable air conditions in large groups of children and adults, sudden temperature contrasts, insensible perspiration, carbon dioxide output, humidity and air freshness, etc., which will be published in the future as time permits.

The mass of data in the present paper is condensed to essential facts in Table 7, and the reader who is interested in facts alone may save much time by referring to this tabulation.

Intensity of Body Odor in Relation to Outdoor Air Supply

(a) Observations with sedentary subjects.

In Fig. 2 are shown the results of experiments with simple ventilation using healthy sedentary subjects over 16 years of age. The data are representative of winter conditions when the air is simply tempered and circulated through the occupied space with or without recirculation. Ordinates in Fig. 2 give the average odor intensity recorded by the judges in each test under equilibrium conditions. Abscissae give the corresponding quantity of outdoor air supplied per person per minute. In most instances the total air supply was 30 cfm per person (black circles) part of which (X) was taken from outdoors and the remaining part ($30-X$) was recirculated. The white circles represent tests in which there was no recirculation.

The first thing to notice in Fig. 2 is that when the odor intensity as perceived by the sense of smell is plotted against the logarithm of the outdoor air supply the relationship is linear. This is in accord with the Weber-

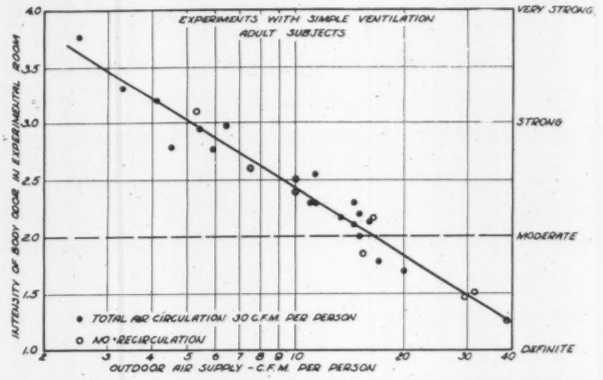


Fig. 2—Outdoor air supply in relation to odor intensity. Net air space per person, 200 cu ft

Fechner law of physiological reactions in general, namely,

Sensation $= K$ log. of stimulus

and by inference

Odor intensity index $= K$ log. of concentration of odor, or

$$\text{“ “ “} = K \log. \frac{1}{\text{outdoor air supply}} \quad \text{and}$$

$$\frac{(\text{O. I.})_1}{(\text{O. I.})_2} = \frac{\log. \text{cfm}_2}{\log. \text{cfm}_1}$$

Translated into words, the strength of body odor perceived by the sense of smell on entering an occupied room from relatively clean air varies inversely as the log. of the outdoor air supply. The same fundamental law applies to the sense of hearing, and it may be of interest to call attention to the fact that our standards for noise and sound have been determined by similar subjective tests using the normal human ear for criterion.

It is seen in Fig. 2 that the body odor was very strong and disagreeable when the outdoor air supply per person was under 3 cfm, the strength decreasing arithmetically as the air supply increased logarithmically. The minimum air supply required to dilute the odor to the allowable intensity of 2 under the given conditions (200 cu ft air space per person, no air conditioning) is about 16 cfm per person. With 30 cfm per person, the odor is still readily detectable but not objectionable.

Recirculation does not seem to affect the odor strength appreciably, as shown by the black and white circles in Fig. 2. In other words, from the standpoint of body odor, a room can be ventilated just as well with an outdoor air supply of 16 cfm per person as with a total supply of 30 cfm, about ½ of which is recirculated. Recirculation is often desirable for adequate distribution and temperature control, but one of the disadvantages is that it smells up the ducts, fans, etc., and unless the system is flushed frequently with clean air, higher air quantities will be needed to obtain satisfactory results.

Sex was not a factor in odor intensity and ventilation

Table 2—Intensity of Body Odor With Men and Women Subjects Under Comparable Conditions

Subjects	Number of Tests	Total Number of Subjects	Air Space per Person Cu Ft	Average Outdoor Air Supply per Person CFM	Average Odor Intensity
Women....	4	23	200	15.8	2.05
Men.....	5	35	200	15.9	2.00

requirements in all instances in which female subjects used no perfumery of any sort, including face powder, before coming to the tests. Results of two series of experiments with men and women subjects, under comparable conditions are shown in Table 2. Similar tests with grade school boys and girls showed no appreciable difference in odor intensity that could be attributed to sex.

(b) Observations with children of average class.

Grade school children between 7 and 14 years old have, apparently an equation of their own. In spite of smaller body surface and lower total metabolism, they give off more odor than the adults and the air requirement is therefore considerably greater. The upper curve in Fig. 3 shows the results on a group of children of average or balanced socio-economic status. The conditions of the experiments were more or less comparable to those in schoolrooms with respect to air space, method of ventilation, activity, etc. The lower curve is reproduced from Fig. 2 for comparison with the results of adults under similar conditions. Whereas in the case of adults an outdoor air supply of 16 cfm per person was sufficient to take care of objectionable body odors, in children the air supply had to be increased to 21 cfm per child.

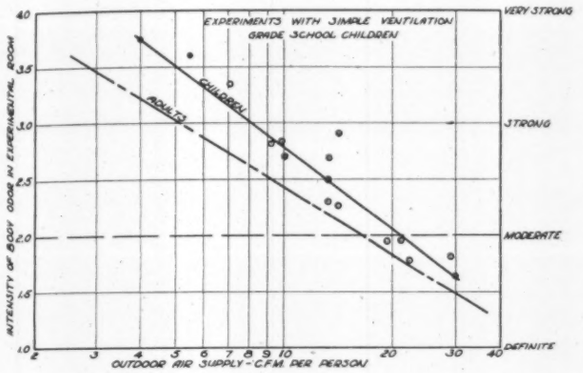


Fig. 3—Outdoor air supply in relation to odor intensity. Net air space per child, 200 cu ft

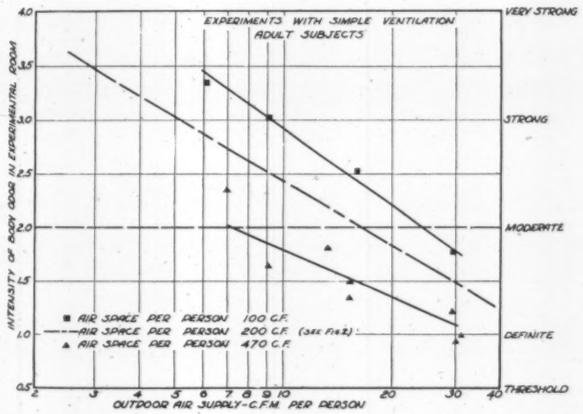


Fig. 4—Influence of air space on odor intensity. Adult subjects

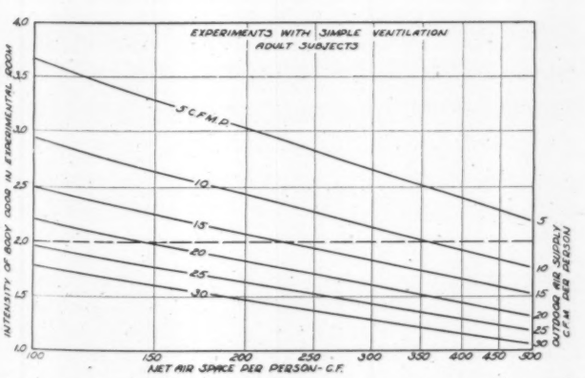


Fig. 5—Chart for computing ventilation requirements of sedentary adults from the standpoint of body odor

Example: Given an air space of 300 cu ft per person, follow vertical line through given air space until it meets the broken horizontal line passing through the allowable odor intensity of 2. The required outdoor air supply per person is 12 cfm obtained by interpolation.

(c) Observations with adolescent children.

Adolescent boys and girls between the ages of 16 and 20 years yielded results closer to those of adults than those of grade school children. In 4 experiments, with a total of 28 adolescent boys and girls, using an air flow of about 10.5 cfm per person, the odor intensity averaged 2.5 $\pm$ 0.13, as compared with 2.4 for the adult subjects (See Fig. 2) and 2.7 for the grade school children (See Fig. 3) under identical conditions. It may therefore be assumed that the requirements of adolescent children and adults are practically the same.

Air Space, Odor Intensity and Ventilation Requirements

(a) Observations with sedentary adult subjects.

The number of persons occupying a room appears to be a very important factor affecting odor intensity and air requirement as shown in Fig. 4. The 3 curves represent results with 3, 7, and 14 subjects in the room, corresponding to floor areas of 11, 22, and 52 sq ft per person and air spaces of 100, 200, and 470 cu ft respectively. The middle curve is reproduced from Fig. 2 without the points.

With 470 cu ft of air space per person, which is more or less representative of conditions in homes, uncrowded offices, and the like, the air requirement from the standpoint of body odor was 7 cfm per person; with 200 cu ft air space, it was about 16 cfm per person, and with 100 cu ft air space, it was almost 25 cfm or 3½ times as great as with an air space of 470 cu ft.

With constant air supply the intensity of body odor varied inversely with the log. of the air space. The relationship is shown in Fig. 5 from which it is possible to compute the ventilation requirements for intermediate densities of occupancy. There is no way to tell, except by actual tests, whether the values would hold with ceiling heights much greater than 10 ft, as for instance in theaters. The diffusion characteristic may be different there.

The striking effect of air space has a sound physical explanation. As has been seen already the intensity of odor perceived by the sense of smell varies with the log. of the concentration. The concentration itself varies inversely with the air space; therefore, the odor intensity and ventilation requirement should vary inversely with the log. of air space, assuming uniform diffusion of the odoriferous matter. Theoretically, doubling the air space is equivalent to doubling the air supply, as in both instances the concentration of odor should be reduced to half. Actually this is not quite the case, as can be seen in Figs. 4 or 5, owing presumably to imperfect diffusion of odors and of the air supplied to the room.

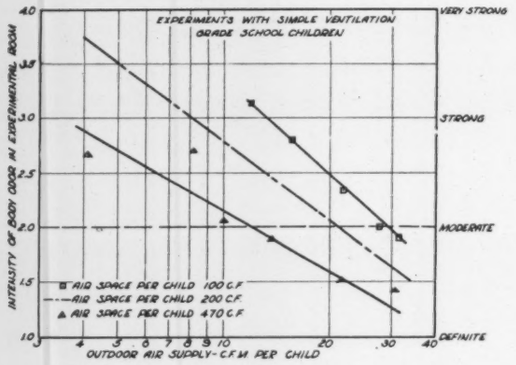

EXPERIMENTS WITH SIMPLE VENTILATION
GRADE SCHOOL CHILDREN
VERY STRONG
STRONG
MODERATE
DEFINITE
INTENSITY OF BODY ODOR IN EXPERIMENTAL ROOM
AIR SPACE PER CHILD 100 C.F.
AIR SPACE PER CHILD 200 C.F.
AIR SPACE PER CHILD 470 C.F.
OUTDOOR AIR SUPPLY - C.F.M. PER CHILD

Fig. 6—Influence of air space on odor intensity. Children subjects

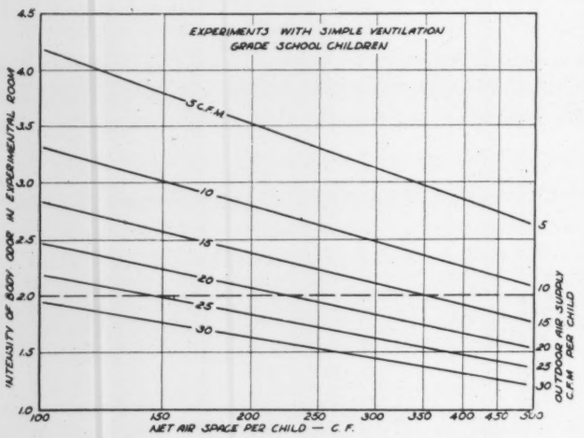


Fig. 7—Chart for computing ventilation requirements of grade school children from the standpoint of body odor. Example in the use of chart shown in Fig. 5

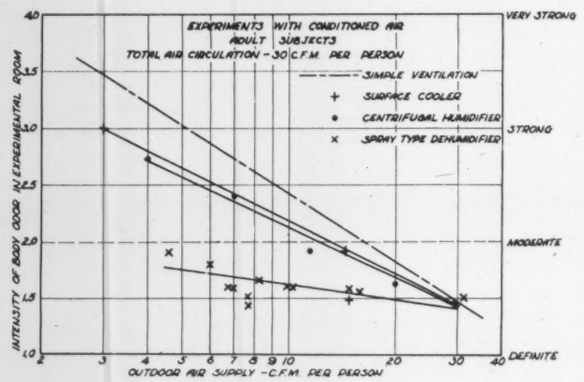


Fig. 8—Odor removing capacity of various air conditioning processes. Net air space per occupant, 200 cu ft

Absorption of odors by walls, furniture, etc. may be other factors.

(b) Observations with children of average class.

Fig. 6 shows a similar picture with children as subjects. Comparison with Fig. 5 will reveal again higher odor intensities and air requirements in children than in adults in all 3 series of experiments. The ventilation requirements for children corresponding to the allowable odor intensity of 2 are

12 cfm per child with 470 cu ft air space
21 " " " " 200 " " " " and
29 " " " " 100 " " " "

as compared with 7, 16, and 25 cfm respectively for adults. Values for intermediate air spaces may be computed from Fig. 7.

The Influence of Air Conditioning Processes on Odor Intensity and Ventilation Requirements

The usual methods of washing, humidifying or cooling recirculated air were found to remove a considerable amount of odor, thus making it possible to reduce the outdoor air supply. Three different arrangements were studied, as follows:

(a) mixture of outdoor and recirculated air passed through a conventional spray-type dehumidifier for cooling and dehumidifying the air of the experimental room in warm weather.

(b) mixture passed through a centrifugal humidifier, for humidifying the air in cold weather.

(c) mixture passed over a surface cooler through which cold water between 35 and 50 deg was circulated. The cooler used in these experiments was capable of lowering the temperature of the air passing over it (210 cfm) through a maximum of about 10 deg.

All 3 series of observations were carried out with 7 subjects in the experimental room (200 cu ft air space per person) and with a total air circulation of 210 cfm, or 30 cfm per person. The temperature range of the cold spray water and of the water circulated through the cooler was between 35 and 50 deg in different experiments. In the case of the centrifugal humidifier the range was 40-55 deg. In order to make the conditions uniform, the spray water was changed before each test and the water tanks of the apparatus cleaned out periodically.

Fig. 8 shows the results. The top curve is again reproduced from Fig. 2 for comparison with the results of simple ventilation, that is with sprays and surface cooler off. The surface cooler absorbed the least amount of odor and the dehumidifier the most. The absorption by the centrifugal humidifier was but only slightly greater than that of the surface cooler. In all instances the surface of the cooler was wet with condensation which dripped to the humidifier tank below and overflowed to the sewer.

The outdoor air requirement was correspondingly reduced from 16 cfm per person with simple ventilation to about 13 cfm per person when the mixture of outdoor and recirculated air was passed through the centrifugal humidifier or over the surface cooler, and to less than 4 cfm per person when the mixture was passed through the spray dehumidifier. In the last instance the odor intensity appears to be almost independent of the outdoor air supply. The performance of the dehumidifier may be more appreciated by calling attention to the fact that the odor intensity cannot be lowered much below 1.5 when the total air circulation is limited to 30 cfm per person, even with a cleaner efficiency of 100 per cent (see Fig. 8). A possibility of olfactory delusion, rather than true odor absorption, cannot be entirely discounted.

While the results obtained with the surface cooler and centrifugal humidifier will probably be realized in actual practice under similar operating conditions, the striking performance of the dehumidifier may be more or less limited by the following factors. The rated capacity of the dehumidifier spray system was about 15 gals per minute per 1000 cu ft of air circulated, but under the conditions of the experiments (210 cfm) the

actual pumping rate corresponded in most instances to about 70 gpm per 1000 cu ft of air circulated. The unusually large pumping rate is probably not an important factor, as in a few tests in which the rate was reduced to the nominal 15 gpm per 1000 cu ft of air, the odor intensity was substantially identical with that of the higher rate. Undoubtedly there is a critical pumping rate, but the data are not sufficient at present to warrant a definite statement.

More important appears to be the cleanliness of the spray water, and water-storage capacity of the dehumidifier tank. In most of the experiments under consideration cold water was pumped to the sprays from a separate brine water-cooler having a storage capacity of 310 gal. The capacity of the dehumidifier tank itself was 10 gal. Another pump returned warm water from the dehumidifier tank to the brine water cooler. It is evident that the odor absorbed by the spray water was greatly diluted, owing to the unusually large water capacity of the brine cooler, and this presumably increased the odor removing capacity of the dehumidifier. The situation may be analagous in the case of large installations in which the spray water is cooled in a separate Baudelot cooler having a large storage capacity. Other factors at work appear to be the degree of flushing of the eliminator plates and the temperature of the spray water itself.

The importance of clean fresh water may be appreciated by the results of an experiment using old water from a previous test, after standing in the brine cooler and dehumidifier tank for 8 days. The outdoor air supply was 12.7 cfm per person, and the average odor intensity rose to 2.10, instead of 1.55 according to Fig. 8. This was the highest odor intensity ever recorded in any of our experiments with the spray dehumidifier. A few subjects in the room were conscious of a *musty* odor in the air even after remaining in the room 3½ hours.

Socio-Economic Factors, Baths, Odor Intensity, and Ventilation Requirements

The observations in Figs. 2 to 8 deal with groups of individuals of average or balanced socio-economic status and habits of personal hygiene. In a special series of experiments an attempt was made to study maximum variations from the average by using a limited number of subjects of the poorest and best class. With adult subjects the two extremes were represented by laborers (janitors and street workers), and medical students. In the case of school children the principal and nurse of a nearby school selected two groups, and we ourselves selected a third one from a different district, a group of children given daily baths and the best of care.

The results of these experiments are presented in Table 3. It will be noted that with equal ventilation rates, the laborers gave off considerably more odor than the medical students, and the ventilation requirements should therefore be greater. The computed air flow necessary to reduce the odor intensity to the allowable limit of 2 is 23 cfm per laborer and 15.5 cfm per medical student, an excess of about 50 percent. The air requirement of the medical students appears to be but slightly less than that of the whole group of sedentary adult subjects (See Fig. 2) probably because the majority of the subjects were medical students.

Table 3—Socio-Economic Status, Baths, Odor Intensity, and Ventilation Requirements

Experiments with Simple Ventilation

Type of Subjects	Total Number of Subjects	Air Space per Person cu ft	Outdoor Air Supply per Person cfm	Average Odor Intensity	Computed Ventilation Requirements cfm per Person	Last Bath Average Number of Days
Laborers	7	200	7.3	3.29	24	7.2
Laborers	7	200	14.4	2.40	22	7.4
Average for Laborers					23	7.3
Medical Students	7	200	7.5	2.60	15	1.3
Medical Students	7	200	14.5	2.11	16	1.2
Average for Medical Students					15.5	1.25
Average Sedentary adult Subject (See Fig. 2)	..	200	....	....	16	2.2
Grade School children of poorest class	7	200	22.0	2.83	38	8.0
Grade School children of "better class"	14	200	20.9	1.87	18	3.0
Average grade school child (See Fig. 3)	..	200	....	....	21	4.2
Grade School children of best class	14	100	16.4	2.34	22	0.8
Average grade school child (See Fig. 5)	..	100	....	....	29	4.9

Table 4—Baths, Odor Intensity and Ventilation Requirements

Experiments with Simple Ventilation

Type of Subject	Air Space per Person 200 cu ft		
	Outdoor Air Supply cfm per Person	Average Odor Intensity	Computed Ventilation Requirement cfm per Person
Grade school children			
0.5 days after bath and complete change of clothing	14.2	2.26	18
6.5 days after bath	14.3	2.90	29
Medical Students			
1.2 days after bath and change of underwear	14.5	2.11	16
7.0 days after bath	16.6	2.18	20

The probable ventilation requirements were computed in the following manner: If the three lines in Figs. 4 and 6 are extended to zero odor intensity, they would all meet approximately on the horizontal scale at about 150 cfm. If now the experimental data of Table 3 are plotted on a chart similar to Figs. 4 or 6, a line joining each of the given points with the common point at 150 cfm would represent the probable relationship under the given conditions. The intersections of these lines with a horizontal line passing through the allowable odor intensity of 2 would then give the probable ventilation requirements under the various conditions.

In a similar manner the requirements of school children were found to vary from 18 to 38 cfm per child, according to socio-economic status, and this reflected objectively upon the bathing habits of individuals as can be seen in the last column of Table 3. To make sure about this point a group of children of average class

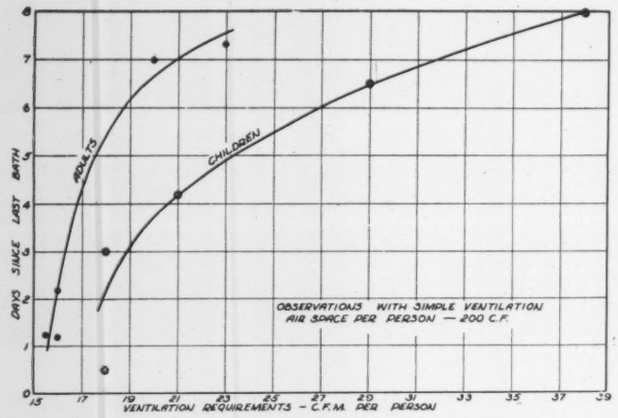


Fig. 9—Effect of baths on ventilation requirements. Requirements based on an allowable odor intensity of 2

and a group of medical students were tested separately, within about a day after a bath and complete change of underwear, and a week later, with no baths or change of underwear in between. The data are summarized in Table 4.

To begin with, the ventilation requirement of the children was about 10 per cent in excess of the medical students, but after about a week the difference increased to 50 per cent approximately, owing presumably to the greater liability of children's clothing becoming soiled, and probably to other factors.

The significance of baths to ventilation requirements may be better appreciated by plotting the data of Tables 3 and 4 on a chart as in Fig. 9. The last two cases at the bottom of Table 3 have been omitted, as the air space differed from the others. The outstanding point in Fig. 9 is that, once the minimum ventilation requirements are fixed for any given conditions, the problem of body-odor control resolves itself to personal factors of hygiene and sanitation. Unfortunately the ventilating engineer has no control upon these factors; as a rule he has to accept the conditions as he finds them and design his system accordingly.

Another important point in Fig. 9 is that the proverbial weekly bath is not at all adequate from the ventilation standpoint, particularly in the case of schoolchildren. Two baths a week would help a great deal in solving the schoolroom odor problem. Unfortunately, there are homes of poor families with no bathing facilities at all. In a group of seven children of the poorest class, 3 frankly volunteered the information that they had to go to a club for their bath once every two weeks or so.

A worthwhile experiment from the standpoint of both economy and education would be to have grade schools in the poorer districts provided with baths and in this way treat the real cause with, perhaps, less expenditure of money, than would be the case with costly ventilation, which after all is temporarily corrective, not preventive. The mothers would then have more time to attend to the laundry of the children's clothing.

Air Quality in Relation to Air Supply and Odor Intensity

In discussing subjective impressions of air quality from the standpoint of air supply, two different viewpoints must be taken into consideration (*a*) that of the visitor upon entering a room from clean air and (*b*) that of the occupant after having become adapted to the conditions of the room. This suggests two ventilation standards both of which are valuable, the choice depending upon the nature of the ventilation problem.

In the present study the primary impressions of air quality were those of the judges; the secondary those of the subjects after exposures of 3½ hours to the air conditions under investigation. The primary or judges' impressions of air quality depended largely on odor intensity when both temperature and humidity conditions in the rooms were suitable.

The quality scale had five grades; *excellent, good, fair, foor,* and *bad,* and also a provision for a negative answer such as *cannot tell.* Air with an odor intensity of 1 was invariably qualified as good or good minus, odor intensity 2 corresponded to fair or fair to good, 2.5 was poor to fair, 3 bad, and 4 very bad. The correspondence was so close that it was found unnecessary to question the judges about air quality. Figs. 2 to 8 may therefore be utilized for illustrating approximately the relationship between primary impressions of air quality and outdoor air supply, by substituting impressions of air quality for odor intensity on the vertical scale.

The subjects, on the other hand, could not, as a rule detect the odor, except when there were 14 of them in the room. Even then however only about a third remarked about odors and the majority in this third were not at all certain whether it was body odor or odors of some other kind. The subjects' criterion of good air was a *freshness complex* perceived by the nose. The most popular reasons for poor air quality, under comfortable conditions of temperature and humidity, were variously described as *stuffiness, closeness, heaviness, lack of freshness,* etc.

Upon entering the room at the beginning of the tests the subjects generally agreed that the quality was good or excellent. The next record near the middle of the test showed a depreciation of quality, and the third record at the end of the test showed but minor changes from the second. Most of the observations on air quality came from college and medical students, an intelligent group of persons capable of analyzing their feelings and voting quite concordantly. Observations from other groups

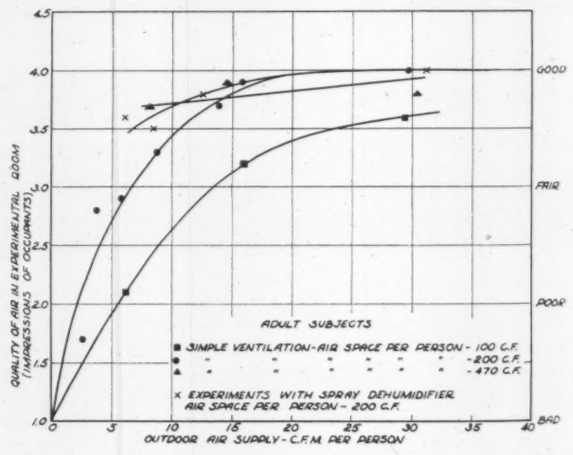

QUALITY OF AIR IN EXPERIMENTAL ROOM (IMPRESSIONS OF OCCUPANTS)
GOOD
FAIR
POOR
BAD
ADULT SUBJECTS
SIMPLE VENTILATION-AIR SPACE PER PERSON - 100 C.F.
" " " " " " -200 C.F.
" " " " " " -470 C.F.
× EXPERIMENTS WITH SPRAY DEHUMIDIFIER
AIR SPACE PER PERSON - 200 C.F.
OUTDOOR AIR SUPPLY - C.F.M. PER PERSON

Fig. 10—Air quality in relation to outdoor air supply under various conditions. Impressions of occupants (subjects) after exposures of 3½ hours to the specified conditions

Table 5—Air Quality, Outdoor Air Supply, and Odor Intensity
Impressions of subjects After Exposure of 3½ hours to comfortable conditions of temperature and humidity

Outdoor Air Supply cfm per Person	Mean Air Supply cfm per Person	Mean Odor Intensity*	Total Number of Subjects	Air Quality Number of Subjects Recording					Mean Air Quality
				Excellent (5)	Good (4)	Fair (3)	Poor (2)	Bad (1)	
	Simple Ventilation tests. Air space per person 200 cu ft								
Under 3	2.5	3.75	7	..	..	1	3	3	1.7
3-5	3.7	3.21	25	..	1	18	5	1	2.8
5-7	5.7	3.08	33	..	3	22	8	..	2.9
7-10	8.7	2.91	14	..	5	8	1	..	3.3
10-15	13.9	2.20	42	1	29	12	..	..	3.7
15-17	15.8	2.02	27	4	16	7	..	..	3.9
29-31	29.7	1.54	15	3	10	2	..	..	4.0
38.7	38.7	1.25	6	..	6	..	..	..	4.0
	Simple Ventilation tests. Air space per person 470 cu ft								
7-9	8.1	2.00	6	..	4	2	..	..	3.7
13-16	14.6	1.55	9	..	6	3	..	..	3.9
29-32	30.3	1.11	6	..	5	1	..	..	3.8
	Simple Ventilation tests. Air space per person 100 cu ft								
6.1	6.1	3.37	14	..	..	4	8	2	2.1
16.0	16.0	2.52	14	..	6	5	3	..	3.2
29.4	29.4	1.78	14	2	5	7	..	..	3.6
	Experiments with spray dehumidifier. Air space per person 200 cu ft								
4-7	6.1	1.72	24	..	14	10	..	..	3.6
7-10	8.4	1.56	26	..	14	12	..	..	3.5
10-15	12.5	1.59	14	..	11	3	..	..	3.8
31.2	31.2	1.51	7	2	3	2	..	..	4.0

*Impressions of judges upon entering room from relatively clean air of threshold odor intensity.

were on the whole less consistent, except under extreme conditions. They could tell definitely when the air was good or poor but as a rule they could not discriminate intermediate grades. Sometimes the answers were negative, such as *cannot tell.*

The quality of air in the control room was always good or excellent (excepting tests in which the temperature was too high or too low), and there was no depreciation of quality throughout the period of the tests. This is to be expected with a constant outdoor air supply of 50 cfm per person in all experiments.

In the classification of the data shown in Table 5, all observations in which the subjects were warm or cold have been excluded, in order to restrict the relationship, as much as possible, to factors pertaining to air quality and outdoor air supply. The results are shown graphically in Fig. 10 which was constructed by evaluating grades of air quality in terms of numbers.

It will be observed that with simple ventilation and with 200 cu ft air space per person, the air quality was poor to bad when the air supply was under 3 cfm per person, improving rapidly as the air supply increased to 15 cfm. Beyond this point further increases in the ventilation rate had little or no effect on air quality, from the standpoint of the occupants, and it will be recalled that from the standpoint of the judges the odor was not objectionable with airflows in excess of 16 cfm (Fig. 2). The general trend is similar when the air space is reduced to 100 cu ft per person, but the air quality is inferior throughout, a situation which is consistent with the higher odor intensity reported by the judges (Fig. 4).

With an air space of 470 cu ft, on the other hand, air quality appears to be practically independent of air supply, in so far as the occupants are concerned, when the period of occupancy does not exceed 3½ hours. An outdoor air supply of 7 cfm per persons was ample from the standpoint of both subjects (Fig. 10) and judges (Fig. 4). The same was more or less true when the air was cooled and dehumidified by passing through the dehumidifier as shown in Figs. 10 and 8.

Tables 6 gives additional observations of air quality, those recorded by the attendant or teacher in the children's experiments. These data are necessarily limited because each test yielded a single observation only, that of the attendant or teacher. In experiments with 3 children, observations of air quality had to be omitted as the children were unattended.

To check this apparent close correspondence between primary impressions of odor intensity and secondary impressions of air quality we plotted the values of these two variables, appearing in Tables 5 and 6, against one another, as shown in Fig. 11. It can be seen that the factors of air supply, air space, as well as those pertaining to individual differences and to air conditioning processes, almost disappear from the picture, indicating that an underlying factor in air quality, when both temperature and humidity are controlled, is the odoriferous organic matter given off by the human body. This is in spite of the fact that the subjects themselves could not smell the odor. Air flow, air space, air conditioning processes, and personal sanitation, are apparently secondary factors affecting the concentration of the odoriferous matter.

In the Study of the N. Y. State Commission on Ventilation, Winslow and Palmer[10] arrived at a somewhat analogous conclusion from an entirely different angle. Quoting from their original report,—"these experiments seem to warrant the conclusion that there are substances

[10]Winslow, C.-E. A., and Palmer, G. T.: Effect upon appetite of the chemical constituents of the air in occupied rooms. *Proc. Soc. Biol. & Med.*, vol. 12, p. 141 (1914-15).

Table 6—Air Quality, Outdoor Air Supply, and Odor Intensity
Impressions of attendant or teacher in children's experiments after exposures of 3½ hours
Observations with Simple Ventilation

Outdoor Air Supply cfm per Person	Mean Air Supply cfm per Person	Mean Odor Intensity	Number of Observations	Mean Air Quality
	Air space per child 200 cu ft			
Under 6	4.8	3.67	2	2.5 (Poor to fair)
10-15	13.0	2.48	5	3.4 (Fair to good)
19-23	21.1	1.91	4	3.8 (Good)
30	30.0	1.65	2	4.0 (Good)
	Air space per child 100 cu ft			
15.7	15.7	2.80	1	3.0 (Fair)
21.8	21.8	2.34	1	3.5 (Fair to good)
31.5	31.5	1.90	1	4.0 (Good)

in the air of an unventilated occupied room (even when temperature and humidity are controlled) which in some way and without producing conscious discomfort or detectable physiological symptoms diminish the appetite for food. The observed beneficial effects of fresh air may to some extent be connected with this phenomenon."

Carbon Dioxide in Relation to Outdoor Air Supply and Odor Intensity

Since the time of Max von Pettenkofer, about 75 years ago, the carbon dioxide content of air in occupied rooms has been widely used as a measure of fresh air supply and a convenient yardstick for the degree of air vitiation by products of organic decomposition from the human body. The value of this index in ventilation work has often been questioned by many workers, and recently by Houghten[11] who showed that changes in the moisture content of air in occupied rooms constitute a more reliable and convenient index of air supply than CO_2 itself. Houghten did not, however, measure the actual CO_2 content of air in his experiments but he computed it from approximate metabolic relationships.

In the present study the actual CO_2 in the air was determined in most experiments near the end of the tests, at different stations inside the experimental room or in the exhaust leading to the corridor. The relationship between CO_2 and outdoor air supply is given in Fig. 12. The curve was drawn from the well known formula

$$\text{Cfm per person} = \frac{100}{CO_2 - 3.5}$$

where 3.5 is approximately the average value of CO_2 in parts per 10,000 as found in the air entering the apparatus before mixing with recirculated air.

Although the theoretical curve roughly averages the experimental points, great discrepancies occur in the steep portion of the curve which happens to be the practical range used in ventilation work. For example, a CO_2 of about 9 parts per 10,000 may mean an actual ventilation rate between 15 and 30 cfm per person, or a maximum error of 100 per cent, depending largely upon the amount of CO_2 given off by the particular group of occupants in the room. The curve is so steep for ventilation rates above 10 cfm, that even small individual variations in CO_2 output correspond to large variations in the air supply. The usual errors in determining CO_2 add to the discrepancies.

For airflows under 10 cfm per person, the discrepancy is not so great, but the computed airflow from the equation is almost always higher than the actual airflow, owing presumably to absorption of CO_2 by the walls, furniture, clothing, etc., when the concentration is high.

As an index of body odor CO_2 appears to be still worse, as can be gathered from the dispersion of the experimental points in Fig. 13. The reasons are quite obvious. Suppose, for instance, that a person takes no bath for a week or two, the odor intensity would be considerably increased (see Fig. 9) but the CO_2 output would barely be affected. Children, for example, in spite of their low CO_2 excretion give off more odor than the adults (Fig. 13) owing largely to differences in bathing habits and cleanliness of clothing, as has been related. On the other hand, when recirculated air is passed through an airwasher, the water removes a considerable portion of the odoriferous matter without affecting much the concentration of CO_2 (Fig. 13.)

In the light of these and other similar data by the New York State Commission on Ventilation, and others, it is evident that a great deal of unjustified effort would be saved by discontinuing the usual measurements of CO_2

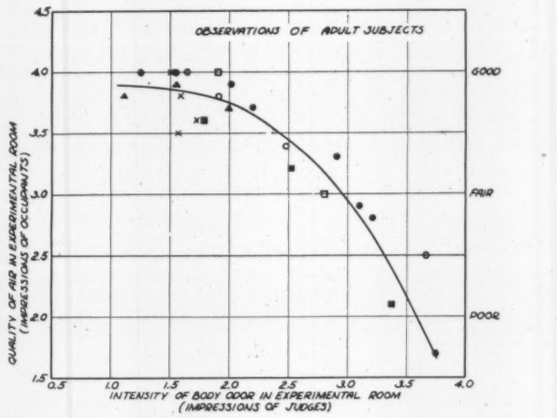

OBSERVATIONS OF ADULT SUBJECTS
GOOD
FAIR
POOR
QUALITY OF AIR IN EXPERIMENTAL ROOM (IMPRESSIONS OF OCCUPANTS)
INTENSITY OF BODY ODOR IN EXPERIMENTAL ROOM (IMPRESSIONS OF JUDGES)

Fig. 11—Relationship between primary impressions (judges') of odor intensity and occupants' impressions of air quality after exposures of 3½ hours. Solid points represent observations of of adult subjects; hollow points are observations of attendant or teacher in children's experiment. Legend shown in Fig. 12

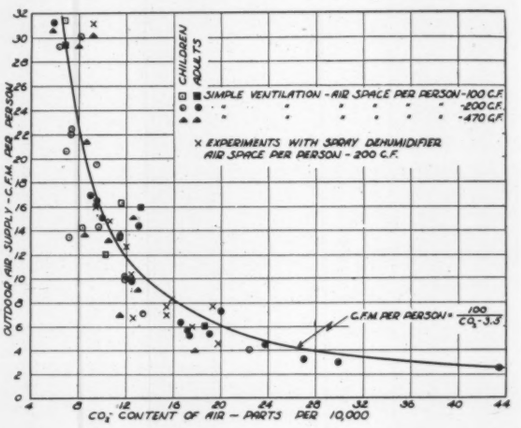

CHILDREN
ADULTS
SIMPLE VENTILATION - AIR SPACE PER PERSON - 100 C.F.
-200 C.F.
-470 C.F.
X EXPERIMENTS WITH SPRAY DEHUMIDIFIER AIR SPACE PER PERSON - 200 C.F.
C.F.M. PER PERSON = 100/CO2-3.5
OUTDOOR AIR SUPPLY - C.F.M. PER PERSON
CO2 CONTENT OF AIR - PARTS PER 10,000

Fig. 12—Carbon dioxide content of air in experimental room in relation to outdoor air supply

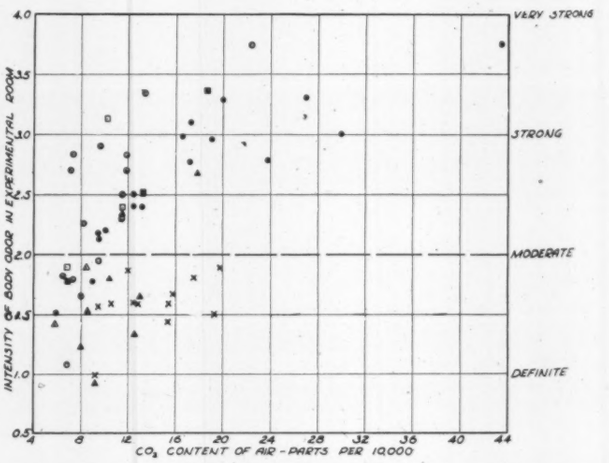


Fig. 13—Carbon dioxide content of air in experimental room in relation to odor intensity. For legend see Fig. 12

[11] Houghten, F. C., and Blackshaw, J. L.: Indices of Air Change and Air Distribution. A. S. H. V. E. Transactions, Vol. 39, 1933.

in ordinary ventilation work, except perhaps in instances in which the airflow is well under 10 cfm per person. Factors pertaining to air distribution can be studied much easier by variations of temperature and air movement from station to station than by variations of CO_2, as outlined in the AMERICAN HEATING SOCIETY OF HEATING AND VENTILATING ENGINEERS GUIDE (1935, p. 51).

The A. S. H. V. E. and Other Earlier Standards

In Table 7 are summarized the ventilation requirements under various conditions as determined in the present study. The impossibility of fixing any single value that would apply under all conditions is evident. Each case would have to be considered on its own merits. The A. S. H. V. E. provisional standard of 10 cfm per person seems to be a more or less fair average value for adult persons where the air space per occupant is between 250 and 500 cu ft per occupant. It falls far too short in grade schools attended exclusively by children of poor districts, assuming that the results are representative, and somewhat too long when the air is cooled and dehumidified in a spray-type air conditioner.

Likewise the results of the present study are not necessarily contradictory to those of the old masters (De Chaumont, Parkes, Billings, and others). The differences in the requirements between then (50 to 30 cfm per pupil) and now (Table 7) are accountable by differences in standards of personal sanitation, as Fig. 9 would seem to indicate.

In the light of the present study, two sets of requirements are suggested as shown in Table 2 to serve two different purposes. In buildings with transient occupants, such as theaters, banks, restaurants, and the like, where the primary impression of the patrons upon entering is of considerable importance, the higher requirements would be better suited in spite of the higher cost. On the other hand, in homes, offices, schools, etc., the lower or secondary requirements may be more desirable from the economic standpoint. Lacking values in Table 7 will be completed soon and weak data will be strengthened and revised in accordance with additional work. The important omission of information on winter air conditioning will also be attended to.

It should be clearly understood that the requirements in Table 7 are average values determined by averaging impressions of a large group of persons. Individual variations will naturally occur; there will always be a few persons who would prefer somewhat higher standards as well as a few others who would be content with lower standards.

Given the specifications of minimum outdoor air requirements under various conditions, the problem would then resolve to recirculating a sufficient amount of air when needed in order to maintain proper temperature, humidity, and air movement. Temperature, in fact, is one of the most important factors in air quality and unless it is controlled the quality will suffer badly no matter what the outdoor air supply, particularly when the air is overheated.

Table 7—Summary of Minimum Outdoor Air Requirements for Ventilation Under Various Conditions

(*Provisional values subject to revision upon completion of work*)

Type of Occupants	Air Space per Person cu ft	Requirements Based on Primary[1] Impressions cfm per Person	Requirements Based on Impressions of Occupants[2] cfm per Person
Heating season with or without recirculation. Air not conditioned.			
Sedentary adults of average socio-economic status	100	25	23
"	200	16	11
"	300	12	..
"	500	7	>5
Laborers	200	23	..
Grade school children of average class	100	29	..
"	200	21	15
"	300	17	..
"	500	11	..
Grade school children of poor class	200	38	..
Grade school children of better class	200	18	..
Grade school children of best class	100	22	..
Heating season. Air humidified by means of centrifugal humidifier. Total air circulation 30 cfm per person.			
Sedentary Adults	200	12	..
Summer season. Air cooled and dehumidified by means of a spray dehumidifier. Total air circulation 30 cfm per person.			
Sedentary Adults	200	>4*	6*

[1] Impressions upon entering room from relatively clean air at threshold odor intensity. Allowable odor intensity = 2 (For scale, see Table 1).

[2] Corresponding to an air quality of fair to good.

* Values provisionally restricted to the conditions of the tests.

Summary

1. The outdoor air requirements for ventilation under comfortable condition of temperature and humidity have been determined from primary impressions of odor intensity upon entering occupied rooms and from impressions of the occupants themselves after exposures of 3½ hours to the conditions investigated.

2. Wide individual variation occurred in the amount of odor emitted by various groups of persons, according to socio-economic status, especially the bathing habits of individuals and cleanliness of clothing. Children, as a rule, gave off more odor than adults, and their bathing habits were deficient.

3. Even healthy clean persons freshly after a bath gave off an appreciable amount of odor which required from 15 to 18 cfm of outdoor air per person in order to dilute it to a concentration that was not objectionable to persons entering the room from relatively clean air. A week after a bath the ventilation requirement of children increased from 18 to 29 cfm, as compared with an increase of from 15 to 20 in the case of adults.

4. With a given group of occupants the intensity of body odor perceived upon entering a room from relatively clear air (air with threshold odor intensity) varied inversely with the logarithm of the quantity of outdoor air supplied and the logarithm of the air space allowed per person.

5. Untreated recirculated air in any amount had no effect on odor intensity or quality of air.

6. The usual processes of washing, humidifying, cool-

ing, and dehumidifying recirculated air apparently removed a considerable amount of body odor and, under certain conditions, practically the maximum amount possible by the use of known processes.

7. Under comfortable conditions of temperature and humidity, both primary and secondary impressions of air quality were found to be related closely to the concentration of odor in the air, despite the fact that the occupants themselves could not smell the odor.

8. Based upon these impressions, two sets of ventilation requirements were derived for various groups of individuals under various conditions as summarized in Table 7. The impossibility of fixing any single standard that would apply under all conditions is clearly evident. Each case, it would seem, must be considered on its own merits.

9. The concentration of CO_2 in the air of occupied rooms proved to be an unreliable index of ventilation, from the standpoint of both outdoor air supply and odor intensity.

Acknowledgment

Most of the preliminary painstaking work was done by Messrs. J. W. Bufford, Gayle Priester, and Joseph Gessner, to whom the authors are greatly indebted.

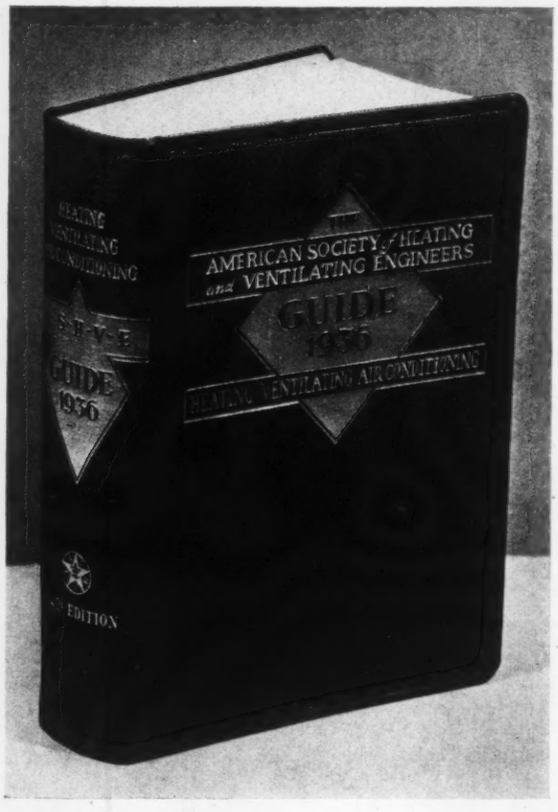
The A.S.H.V.E. Guide 1936

Distribution of THE GUIDE 1936 to members of the Society will commence January 25 and in this fourteenth edition they will find that a large amount of new and revised authoritative engineering data have been assembled from a variety of sources on the subjects of heating, ventilating and air conditioning, increasing the contents of the Technical Data Section to 792 pages. The engineers and technicians who compiled this new volume have drawn upon the latest researches of the A. S. H. V. E. Laboratory and cooperating institutions with correlating design and application data based on the most recent engineering trends in this expanding industry. The Problems in Practice introduced last year have been continued for each chapter with new and practical examples to amplify the text material.

Four new chapters have been added to THE GUIDE 1936 to fulfill the requests for more detailed information on the subjects of Refrigeration, Drying, Electric Motors and Railway Air Conditioning. Included in the chapter on Refrigeration are descriptions of the various theoretical and practical cycles with illustrated diagrams and complete thermodynamic tables of the most common refrigerants. Special consideration is also given to absorption, adsorption, steam ejector and reverse cycle systems of refrigeration. The chapter on Railway Air Conditioning discusses the most recent trends in passenger car installations as related to ventilation, heating, cooling and control requirements. Dryer construction and design with operating methods and mechanisms of control are described in a new chapter. A new temperature and humidity chart which may be applied to all types of dryer calculations with a complete descriptive example is fully illustrated. Direct and alternating current motors and their controls which may be used in connection with various types of heating, ventilating and air conditioning apparatus are amply covered in the chapter on Motors.

Another feature of THE GUIDE 1936 is the new table of Saturated Water Vapor extending over a range from minus 130 to plus 200 F with heat content values based on the varying values of specific heat for air. As a result of a comprehensive survey of cities in the United States and Canada, a table has been added giving the maximum city water main temperatures for direct application to cooling apparatus.

In addition to the new material which has been added, the previous chapters have been carefully checked and reviewed and in some cases the text has been completely rewritten so as to conform to more recent engineering practices. All of the information on unit heaters, ventilators, coolers and air conditioners has been correlated



in one chapter with several additional sketches to illustrate the units now available. System characteristics of fans with curves to illustrate the effects of speed or system changes on fan operation have been added. New illustrations of air supply grilles and openings are covered in the revised chapter on Air Distribution. The information on stokers and oil burners has been expanded with new cuts to show typical units. A complete revision of the chapter on Heat and Fuel Utilization provides two methods for estimating the fuel consumption of the various types of buildings and for various types of fuels. The degree-day table for cities in the United States and Canada has been amplified so as to segregate the monthly values for each city. Swimming pools, hot water heaters and a revised method of proportioning pipe sizes for domestic cold and hot water systems are given.

The 260 pages of Catalog Data include descriptive matter on the products of 181 leading manufacturers and are a valuable adjunct to the Technical Data Section. This new volume of 1,092 pages is bound in an attractive blue flexible cover stamped in gold foil.

NOMINATIONS FOR 1936

The Nominating Committee appointed to select candidates for Officers of the Society for the coming year, 1936, submits the following list of nominees:

For President:

G. L. LARSON, Madison, Wis.

For First Vice-President:

D. S. BOYDEN, Boston, Mass.

For Second Vice-President:

E. H. GURNEY, Toronto, Ont., Can.

For Treasurer:

A. J. OFFNER, New York, N. Y.

For Members of the Council:

Three-Year Term

R. C. BOLSINGER, Norristown, Pa.
S. H. DOWNS, Kalamazoo, Mich.
W. L. FLEISHER, New York, N. Y.
C. M. HUMPHREYS, Pittsburgh, Pa.

Respectfully submitted,

NOMINATING COMMITTEE,
E. A. JONES, *Chairman;*
R. J. TENKONOHY, *Secretary.*

In accordance with the provisions of the Amended Constitution, as given, ballots containing the names of the above candidates will soon be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. B-VIII—Section 10. The Nominating Committee shall consist of one (1) member eligible to vote designated by each Chapter, or his alternate also appointed by the Chapter. The Secretary of each Chapter shall certify to the Secretary of the Society on or before January first the names of the member and alternate selected.

The Committee shall meet at the Annual Meeting of the Society at the call of the Secretary of the Society and shall effect its own organization and elect its own Chairman. At the Semi-Annual Meeting of the Society, if possible, the Nominating Committee shall select the nominees for the ensuing year for the offices of President, First Vice-President, Second Vice-President, Treasurer, and four (4) members of the Council. In any event the names of the nominees shall be certified to the Secretary of the Society before September twentieth, with the written consent of each nominee to fill the office for which he has been selected and their names with the offices to which they have been nominated shall be published in the October issue of the JOURNAL.

Art. B-IX—Section 2. The Secretary shall prepare ballots with the names of all candidates and forward them to the members, eligible to vote, at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election.* The election is governed by the By-Laws for the election of officers, with the single exception that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee.

In accordance with the Regulations for the Government of the Research Laboratory, adopted at the January, 1919, Meeting, and amended January, 1933, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January, 1936:

Three-Year Term

W. A. DANIELSON, Washington, D. C.
C. E. LEWIS, Dayton, Ohio.
D. W. NELSON, Madison, Wis.
CYRIL TASKER, Toronto, Ont., Can.
C.-E. A. WINSLOW, New Haven, Conn.

The regulations governing the nomination and election of members of the Committee on Research are as follows:

ARTICLE II—ORGANIZATION

Section 1. *Committee on Research*—There shall be a standing committee known as the Committee on Research, consisting of fifteen (15) members each serving for three (3) years and five (5) retiring each year. The outgoing Chairman if serving in that capacity during the last year of his three (3) year term on the Committee shall without election become an additional member of the Committee on Research for one (1) year.

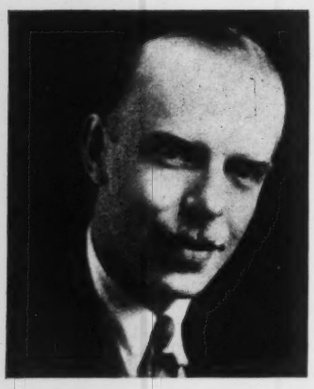
(*a*) The Council shall nominate previous to July first of each year five (5) members to fill the vacancies of those retiring at the next Annual Meeting.

(*b*) The nominations made by the Council shall be published in the October issue of the Society's JOURNAL.

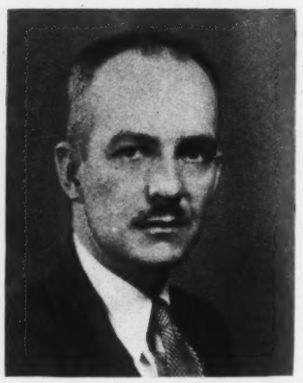
(*c*) Any ten (10) members of the Society eligible to vote may present to the Secretary over their signatures, the name of one (1) or more additional nominees for the Committee on Research, provided such name or names are presented at least sixty (60) days prior to the next Annual Meeting, and such additional nominations shall be placed on the ballot opposite the nominations made by the Council.

(*d*) The election shall otherwise conform to the regulations provided for the election of officers of the Society in the Constitution, By-Laws and Rules.

(*e*) Vacancies may be filled by the Council, such persons chosen by the Council to serve until a successor is elected at the next Annual Meeting.



Tom Brown, *Entertainment*

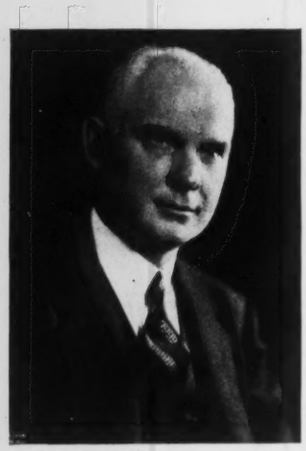


Carl F. Hayden, *Ladies*

J. R. Vernon, *Reception*

YOUR HOSTS

John Howatt, *President*



J. H. Milliken
General Chairman

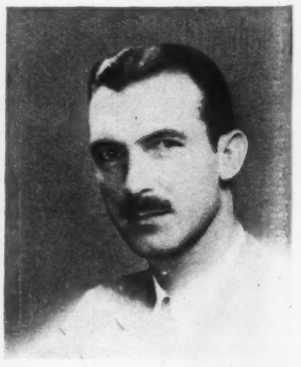
J. J. Hayes
Vice-Chairman

ILLINOIS CHAPTER

Elmer W. Rietz, *Finance*

J. P. Fleming, *Banquet*

Byron L. Casey, *Transportation*



C. E. Price, *Publicity*

42nd Annual Meeting in Chicago

Palmer House **January 27—30**

Meeting headquarters—the Palmer House

EVIDENCE that is accumulating indicates a record attendance for the Society's 42nd Annual Meeting when it is called to order by Pres. John Howatt at the Palmer House, Chicago, January 27, at 10 a. m.

The Committee on Arrangements of Illinois Chapter headed by J. H. Milliken has worked energetically to provide appropriate entertainment for visiting members and guests. A technical program of unusual interest has been arranged by the Program Committee, of which Albert Buenger is chairman.

Members who go to Chicago should make hotel reservations at the Palmer House on the special cards mailed to them and should present Identification Certificates furnished through the Headquarters office to local ticket agents in order to purchase round trip tickets at the reduced rate of fare and one-third.

These Identification Certificates may be used from all parts of the United States and Canada. Members should inquire of local passenger agents for dates of sale of tickets. Tickets are good for 30 days and may be used on *one* specified route to Chicago on the going trip and *another* specified route returning if this plan is requested at the time of purchasing ticket. All return coupons must have a validation stamp which can be made at any railway ticket office in Chicago and at the ticket agent's office in the Palmer House lobby.

Members should register, receive programs and purchase tickets for the various functions, such as the House Warming Party Tuesday night and the banquet and dance Wednesday evening. Tickets for these social functions can also be obtained at the Society's information booth No. 8 at the Exposition in the International Amphitheater.

The week of January 27 will be a Big Week in Chicago for everyone engaged in the heating, ventilating, air conditioning and refrigerating fields. For complete details of the program and information about exhibits and exhibitors see the special tinted stock section in this issue.

J. H. Milliken is General Chairman of the Committee on Arrangements of the Illinois Chapter, and J. J. Hayes is Vice-Chairman. Chairmen of the committees in charge of the various functions are:

Reception, J. R. Vernon; *Transportation,* Byron L. Casey; *Banquet,* J. P. Fleming; *Ladies,* Carl F. Hayden; *Entertainment,* Tom Brown; *Finance,* Elmer W. Rietz; *Publicity,* C. E. Price.

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting:

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the sale of tickets for group features be discouraged.

6—That the raising of funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter or local members, be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

New Firm of Buensod-Stacey

Announcement was made on December 13 of the incorporation of the Buensod-Stacey Air Conditioning, Inc., with headquarters in the Lincoln Building, 60 East 42nd St., New York, N. Y.

This new corporation will operate as a personal service organization in the air conditioning contracting field. The personnel of this organization has had many years' experience in every air conditioning application through their former connection with Carrier Engineering Corporation:

Alfred E. Stacey, Jr., pioneer research engineer and associated with Willis H. Carrier for over 25 years. The researches of Mr. Stacey cover the application of air conditioning to the manufacture of textiles, ceramic drying and over 200 other industrial processes; also the application of air conditioning for comfort.

M. S. Smith, for many years the purchasing agent and production manager, and of late years the treasurer.

A. C. Buensod, specialist in the application of air conditioning to the tobacco industry; also pioneer in the development of air conditioning for theatres, motion picture film and sound stage production.

R. O. McGary, assistant tobacco specialist and air conditioning engineer.

H. W. Marshall, formerly chief engineer of the Oriental Carrier Engineering Co., Limited, of Japan, and recently chief engineer of the New York District Office.

J. C. Rose, designing engineer for various air conditioning applications and specializing in theatre work.

W. O. Hoffman, designing engineer for various air conditioning applications and specializing in adjustment of systems—included among these were Radio City Theatres and National Broadcasting Studios.

S. E. Lyman, air conditioning engineer with 18 years' experience in all types of intricate air conditioning applications which include processing, drying and comfort work.

John Wislotski, construction engineer with 15 years experience in the installation of air conditioning equipment.

This group of engineers propose to specialize in those industries in which they have had long experience and also engage in the application and development of air conditioning for comfort. The officers of the corporation are: A. C. Buensod, President; Alfred E. Stacey, Jr., Vice-president; M. S. Smith, Treasurer; H. W. Marshall, Secretary.

Death of Konrad Meier

Word of the death of Konrad Meier of Winterthur, Switzerland, on November 27, 1935, has recently been received and the profession will feel the loss of one of its leading consulting engineers. Mr. Meier died unexpectedly of heart trouble and his body was cremated on November 29. He is survived by two sisters as well as several nephews and nieces. Mr. Meier was internationally known through his work both in this country and abroad and many of his contributions to the technical literature are to be found in the Society's TRANSACTIONS and in the proceedings of other engineering organizations. He also was the author of Mechanics of Heating and Ventilating.

He was a native of Winterthur, Switzerland, where he was born on February 9, 1866. He received his education in the local schools and colleges. His long experience in the field of engineering began when he was engaged in general machine work with Sulzer Bros., Winterthur, from 1884 to 1886 and in the heating and gas department of the same company from 1886 to 1889. He was associated with R. O. Meyer, Hamburg, Germany, as assistant engineer from 1889 to 1890 and with Mannot & Co., Paris, France, as engineer from 1890 to 1891.

In 1891 Mr. Meier came to the United States and for two years he was connected with the Boston and Philadelphia offices of B. F. Sturtevant Co.

For a number of years he was located in New York City as chief assistant to Alfred R. Wolff during 1894 to 1904 and then as a consulting engineer from 1904 to 1912.

Returning to his home in Winterthur, Switzerland, Mr. Meier continued his activities as a consulting engineer until the time of his death.

In 1916 Mr. Meier joined the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS as a Member and he always kept in close contact with professional activities in this country, evidencing his great interest in heating and ventilating engineering. He was also a member of the *American Society of Mechanical Engineers.*

PRESIDENT'S MESSAGE TO MEMBERS

ANNUAL MEETING AND EXPOSITION

During the last week of this month the interest of the Society will be centered on the activities in and about the 42nd Annual Meeting and the 4th International Heating and Ventilating Exposition.

Attendance at this meeting will give each the opportunity of taking part in the technical sessions and discussing the reports and papers, meeting and conversing with others interested in the same things in which you are interested, enjoying the entertainment provided for you and your ladies by the Illinois Chapter and visiting the Heating and Ventilating Exposition. Both the Meeting and the Exposition already give indications of being among the best in the history of the Society.

The Annual Meeting has come to have an important place in our affairs not only because of its effects on our technical and research programs, but also because of the opportunity it provides for personal contacts and the solidification of the geographically widespread units in our Society.

Every member should plan on being in Chicago, if possible, during the last week in this month. It will be to your advantage. The Illinois Chapter will give you royal welcome.

John [illegible] — President,
AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

January 1, 1936

Local Chapter Reports

Cleveland

November 11, 1935. Twenty-one members and guests attended the dinner and business meeting preceding the open meeting held at the Cleveland Club.

The business meeting opened with the reading of the minutes of the previous meeting, which were accepted.

Secy. Philip Cohen read a communication from headquarters office, advising that the Guide Publication Committee had accepted the recommendations of the Cleveland Chapter Standards Committee that the design wet-bulb temperature for Cleveland be considered as 75 deg wet-bulb.

Applications for membership in the local Chapter from the following men were announced: W. R. Beach, J. L. Foley, E. W. Gray, J. G. Harris, Hugh Lenane, F. K. Minor, W. M. Rowe and R. A. Wilson. All of these candidates were unanimously voted into the Chapter.

In accordance with the requirements of the Society's Constitution and By-Laws, L. T. Avery moved that M. F. Rather represent the Cleveland Chapter on the National Nominating Committee, with C. A. Eveleth as alternate. The motion was seconded by W. E. Stark and carried.

In accordance with the regulations of the Council allowing an executive officer of local chapters to represent the chapter at the Annual Meeting, a motion was introduced by Mr. Avery that Treasurer H. M. Nobis be designated. The motion was seconded by F. R. Dickenson, and carried.

The following amendment to the Chapter By-Laws was introduced for consideration at the next meeting: "A classification shall be set up for student members who shall enjoy all privileges as members, except they shall not vote nor hold office. Dues for student members shall be $1.00 per year payable in advance."

As required by the Constitution, the amendment was introduced by three members in good standing: J. A. Schurman, H. M. Nobis, and L. T. Avery.

H. E. Wetzell of the Standards Committee, called attention of the members to the paper on Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet, based on research at the Society's Laboratory at Pittsburgh.

J. A. Robinson of the Australian Gas Light Co., Sydney, Australia, a guest at the meeting, was introduced and spoke briefly.

The business meeting was then adjourned.

Seventy-five members and guests attended the open meeting at which the speaker was W. G. Frank, Assistant Chief Engineer, American Air Filter Co. His subject was Air Cleaning Methods and Devices.

Mr. Frank gave a very interesting illustrated talk on types of dusts, their classification and measurement by weight. He then discussed four common types of air filters, namely: viscous automatic filters, viscous manually cleaned filters, viscous renewable filters, and dry type filters.

Mr. Frank outlined several well-known methods for determining filter efficiency and pointed out that all of them have definite limitations. He then referred to test methods of the A.S.H.V.E. and the U. S. Bureau of Standards as more recent and indicative of true efficiency. He brought up the application of filters and quoted the specification issued August 1, 1935 by the Procurement Division, Public Works Branch, U. S. Treasury Department. These specifications list filters as follows: (1) For capacities above 20,000 cfm; viscous automatic filter; (2) For capacities less than 10,000 cfm; throw away type filter. Exception: court room supply; (3) For capacities from 10,000 to 20,000 cfm: dry type filters with replaceable media. Exceptions: (a) Where air is taken from near street level, use viscous automatic filters; (b) court room supply; (4) For supply to court rooms and judge's chambers: dry type filters with permanent vacuum cleaned media. Exception: Where fresh air is taken near street level, use viscous automatic filters.

Mr. Frank concluded his talk with a discussion of various factors determining the selection of a filter for a specific application.

Philip Cohen then gave a short talk on the Air Washer as an Air Cleaning Device. Mr. Cohen outlined briefly the various types of commercial washer designed especially for humidifying or dehumidifying service rather than for cleaning efficiency. He discussed the scrubber type air washer designed especially for cleaning efficiency. He pointed out that in contrast to air filters, the efficiency of the air washer as a cleaning device has been measured by results of the application rather than by dust count. Mr. Cohen concluded his talk with a description of a new development in air washers; a combination of spray nozzles and bronze wool filter media.

The next speaker was J. A. Schurman, who discussed the Use of Filters in Air Conditioning Installations. Mr. Schurman raised pertinent questions on the application of filters such as: Is it necessary to filter recirculated air as well as outside air make up?; Is it preferable to use separate filters for outside air?; Should a different type filter be used for recirculated air? Mr. Schurman discussed these questions and then Mr. Frank offered additional comments.

Mr. Avery, Chairman of the Chapters' Standards Committee, introduced a letter from the Committee proposing a standard for air cleaning in connection with an air conditioning system, which was submitted for the Chapter's consideration.

The meeting adjourned at 11:00 p. m.

Illinois

December 9, 1935. The meeting was called to order at 7:55 p. m. by Pres. J. H. Milliken. He welcomed the air conditioning engineers who were guests of the evening and Mr. Hines, *A.C.E.* President, responded. President Milliken then welcomed the *A.S.R.E.* members to the meeting and Mr. Primm, the President, responded as did Mr. Seamon, Secretary. Tom Hart, instructor at the Chicago Technical College, whose class on air conditioning had been invited to the meeting, acknowledged an introduction by President Milliken. W. E. Stark of Cleveland, a member of the National Council of the A.S.H.V.E. was present and introduced to the meeting.

R. E. Hattis moved that the reading of the last month's minutes be dispensed with, which was seconded and carried.

President Milliken then called upon Secy. L. S. Ries to outline, briefly, the items of significance in the Milwaukee Meeting and the Rump Meeting held on the train coming from Milwaukee to Chicago.

J. J. Finan and E. T. Murphy, members of the national organization, who had made application to the local chapter for membership, were welcomed into Illinois Chapter.

Ten Limited Members, Messrs. Storch, Philippi, Kolwitz, Krogman, Sunderland, Gustafson, Kincaid, Crump, Burnam, Jr., and Anderson, were welcomed into the Chapter.

At 8:15 p. m. President Milliken turned the meeting over to John Howatt, President of the A.S.H.V.E., for presentation of the paper, Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet. President Howatt announced that this paper was being discussed in all of the Chapters of the Society during the month. As a member of the Committee on Research, President Howatt found that one of the most controversial items was the subject matter of the paper and because of the interest manifested in this subject, it was placed on the 1935-36 Research Program at the Committee's Buffalo Meeting. It was decided to have the research completed as soon as pos-

sible in order that the findings might be discussed by all of the chapters in the country previous to the Annual Meeting in Chicago in January, 1936.

President Howatt stated that the comfort chart had been adopted by the Society about 12 years ago. This chart established the limits of temperature and humidity in still air but did not take into account the outside dry-bulb temperature. With the aid of a series of seven slides, illustrating the curves in the article, President Howatt brought out the shock experience, by all of the steps, in going from a warm inside temperature to the cool air and followed through in detail the most significant steps of the research.

After President Howatt completed his remarks, Dr. E. V. Hill took the floor and he stated that in his opinion, the term *effective temperature* was a psychrometric error. Dr. Hill's criticism of the paper was that five interested students had been used for subjects. These students unconsciously were probably influencing the result because of their interest. For that reason Dr. Hill preferred subjects who are not familiar with the effects involved. In his opinion this type of subject would be more apt to give unbiased answers. The lag shown in the charts was undoubtediy due to the wearing of clothing by the subjects and Dr. Hill suggested that nude subjects should be used.

Harry Hart, Past President of the Chapter and a member of the Chicago Committee on Air Conditioning Standards, thought that the conditions under which tests were run were not applicable to the requirements for most air conditioning installations. As the young men were in a sparsely occupied space, he considered the results of doubtful value when applied to an auditorium where large groups of people are in close proximity. He believed that if, in setting standards for air conditioning, the dry-bulb temperatures were eliminated entirely and wet-bulb temperatures substituted, a great benefit would be done to the industry. Mr. Hart found, as a result of this paper, that the industry should limit itself for design, between relative humidities of 30 and 60 per cent. He considered that one of the deficiencies in the experimental data is that no consideration was given to air in motion. Mr. Hart concluded by stating that the Research Laboratory should be highly commended for this excellent paper and urged to continue the work on this very important subject.

John Aeberly stated that the paper was not conclusive. Years ago when the Chicago Board of Health stated that the wet-bulb temperature is the one that should be used for comfort control in air conditioning, great protest was aroused. He thought this paper emphasized the correctness of the Board of Health statement. This paper further refines margins of the comfort control established in THE A.S.H.V.E. GUIDE. Replying to Dr. Hill's comment on the type of subjects used, Mr. Aeberly stated that, in his opinion, the subjects and Research staff were serious and not in coalition in any way to affect the results.

V. L. Sherman of the Lewis Institute thought that the authors of the paper were to be commended for their reasonable direction and careful work, as well as because they are not satisfied with their present conclusions but suggest further experimentation to check the results. In his opinion the effect on the human body of air conditioning has not had sufficient attention, and more collaboration with the medical profession is suggested.

Secy. L. S. Ries thought that in the discussion barometric pressure variations should be included as these pressure variations undoubtedly had a marked effect on comfort.

Mr. Hattis suggested that a standard should be established in which the average person is healthiest as well as most comfortable.

Martin Brown thought that the temperature differential between the outside and the inside air should be closely limited for comfort and suggested that studies should be made with male and female subjects of different age groups.

Major Stark expressed his opinion that no matter what conclusions were reached they would be vulnerable to attack, and no matter how disinterested the subjects tried to be they were sure to be influenced by their knowledge of the state of the art. He would rather have had as subjects, comparative morons.

President Howatt then briefly summed up the major points of the discussion. He further stated that the 42nd Annual Meeting of the Society was to be held at the Palmer House, beginning January 27, 1936, and he invited everybody present to attend both the Meeting and the Exposition.

The meeting adjourned at 10:20 p. m.

Michigan

December 16, 1935. About 55 members and guests attended the dinner meeting of the Michigan Chapter at the Wardell Hotel.

After roll call, the minutes were read and approved.

Pres. A. C. Wallich read a communication from the *Associated Technical Societies* of Detroit calling attention to a meeting to be held later for the benefit of high school juniors and seniors who are considering entering the engineering profession.

President Wallich also read a communication from National Headquarters regarding the exchange service plan with the *American Society of Refrigerating Engineers,* and he also called attention to the fact that the next summer meeting of the Society will be held in conjunction with the *A. S. R. E.*

Tom Brown, formerly of the Michigan Chapter who is now located in Chicago, spoke on arrangements for the Annual Meeting of the Society in Chicago in January.

President Wallich appointed as delegate to the Annual Meeting, and as representative on the Nominating Committee from the Michigan Chapter, Thomas Chester, with George Tuttle as alternate.

The speaker of the evening was S. S. Sanford, who discussed the paper on Comfort Standards for Summer Air Conditioning prepared by the A. S. H. V. E. Research Laboratory. He traced the origin of effective temperature and by means of charts explained the tests being conducted by the Society. Following his paper there was considerable discussion on this subject by Messrs. Chester, Rowe, Walker, Harrigan, McIntire, Keilholtz, Toonder, Helmrich and Wells.

It was moved, seconded and passed that the Michigan Chapter go on record as commending the research being done by the Society on this project and urging a continuance of the studies.

The meeting adjourned at 10 p. m. according to the report of Secy. W. F. Arnoldy.

Massachusetts

November 21, 1935. A joint meeting of the Massachusetts Chapter of the A.S.H.V.E., the Air Conditioning Bureau, the *Boston Oil Burner Association* and the local section of the *A.S.M.E.* was held at the Hotel Kenmore, Boston, Mass.

Dinner was served to 309 members and guests and approximately 450 persons attended the meeting.

Julius Daniels introduced W. T. Jones, who greeted the gathering in behalf of the A.S.H.V.E.

The meeting was then turned over to the Chairman of Papers and Meetings Committee, Prof. Philip Drinker. S. M. Anderson was presented by Mr. Drinker and discussed Railroad Air Conditioning.

Mr. Anderson stated that passenger traffic on lines employing air conditioned cars had increased from 40 per cent to 300 per cent in all sections of the country. Slides were presented, tracing the history of railroad air conditioning and showing early installations in 1910 as well as modern methods employing both mechanical and ice refrigeration.

Several questions were asked regarding the amount of outside air used and Mr. Anderson stated this was customarily set at about 25 per cent, which seemed to provide satisfactory comfort conditions without exceeding the limitation of the power available.

The December meeting of the local chapter was announced to be held at Massachusetts Institute of Technology.

Edward Roemer, Building Commissioner of the City of Boston,

then expressed the interest of his department in the rapidly advancing field of air conditioning.

Mr. Roemer sounded a warning in regard to the fire hazard of improperly installed ductwork and suggested that a committee of air conditioning engineers be appointed to consult with a committee of structural engineers and collaborate with his office in developing proper safeguards.

Mr. Daniels introduced many prominent engineers, real estate operators, contractors and public building executives who are interested in the development of air conditioning. He then presented W. L. Fleisher, consulting engineer, New York, N. Y., who discussed the Changing Aspects of Air Conditioning.

As outlined by Mr. Fleisher, air conditioning originated in industry and was closely allied with refrigeration. It was first introduced in 1923 in theaters and at that time the first studies of comfort work were carried on by the Society.

Mr. Fleisher urged that every effort be made to enlist the interest of the medical profession in order to popularize the necessity and benefits of air conditioning. He also pointed out the tendency to a smaller drop in temperature and larger supply of circulated air and smaller amount of refrigeration and suggested further development of the possibilities offered by the control of humidity and air motion.

Particular emphasis was placed on the investigation of means to bring air conditioning within the range of purchasing power of the public.

In conclusion, Mr. Ryan briefly explained the design of the air conditioning system recently installed in the Hotel Kenmore. An invitation was extended to all present to inspect the system, according to the report of G. B. Gerrish, Secretary.

Philadelphia

December 12, 1935. The regular meeting of the Philadelphia Chapter was held at the Engineers Club with Pres. J. H. Hucker presiding.

V. L. Sanderson of the *Engineers Musical Association* spoke, urging support.

The minutes of the previous meeting and the Treasurer's report were read and approved.

Pres. John Howatt's December letter to chapters was read by the Secretary, H. H. Erickson.

R. F. Hunger, Chairman of the Membership Committee, reported a total of 22 new Society members and 15 Chapter members and urged continued activity on the part of the teams to increase membership.

A. H. MacDade, of the Attendance Committee, advised that 25 members had dinner and 36 were present at the meeting.

It was regularly moved and seconded and duly passed that the present officers and committees remain in office until the annual election in April, 1936.

Secretary Erickson, a member of the Year Book Committee, spoke in behalf of its publication and asked members to cooperate in making its publication a success.

S. E. Plewes announced the inability of the scheduled speaker, C. S. Leopold, to attend. Mr. Plewes introduced P. L. Davidson, whose paper on Air Conditioning was well received. A rising vote of thanks was given Mr. Davidson for the presentation of such an excellent paper.

President Hucker adjourned the meeting at 9:45 p. m.

November 14, 1935. With Pres. J. H. Hucker presiding, a joint meeting was held with the local chapter of the *American Society of Refrigerating Engineers* at the Engineers Club. Preceding the business session, an excellent dinner was served in the meeting room, with 100 members and guests present.

Upon motion duly made by J. D. Cassell, seconded by M. F. Blankin, the Constitution and By-Laws of the Philadelphia Chapter were changed as follows:

Article V—Section 1: Regular monthly meetings shall be held in Philadelphia on the dates and at the place selected by the Board of Governors from October to May inclusive. The April meeting shall be the annual meeting of the Chapter, at which time officers shall be elected.

Article VII—Section 1: At the October meeting in each year, a Nominating Committee of five members shall be elected by the Chapter.

Article VII—Section 4: The candidate receiving the highest vote for each office shall be declared elected, and shall take office at the beginning of the May meeting, but shall be inducted into office as part of the closing ceremonies of the April meeting.

Secy. H. H. Erickson was instructed to advise headquarters office of these changes.

President Hucker introduced Howard Leslie, Rio de Janeiro, Brazil, who told of engineering activities in Brazil.

President Hucker then turned the meeting over to S. E. Plewes, who presented the speaker, Harry Harrison, President of the *A.S.R.E.* Mr. Harrison read the paper prepared by the A.S.H.V.E. Research Laboratory on Comfort Standards for Summer Air Conditioning. The paper was illustrated by slides and was well received. Among those taking part in the discussion were A. E. Stacey, C. S. Leopold, M. G. Kershaw, H. Leslie, H. H. Mather, F. D. Mensing, S. H. Knight, E. S. Bigelow, and Harry Harrison.

This meeting proved to be one of the most interesting held in some time. A rising vote of thanks was given to Mr. Harrison for his presentation, before President Hucker adjourned the meeting at 9:50 p. m.

Ontario

December 2, 1935. Forty-one members and guests were present at the regular meeting of the Ontario Chapter held at the Royal Connaught Hotel, Hamilton, Ontario.

At 4:30 an inspection trip was made of the Dominion Foundries & Steel Ltd. At 6:30 p. m. dinner was served at the Royal Connaught Hotel.

O. L. Maddux introduced the principal speaker of the evening, R. T. Kelly, who spoke on Canada's Future. L. L. Anthes extended a vote of thanks to Mr. Kelly for his inspirational talk.

Pres. M. W. Shears read Pres. John Howatt's letter entitled, Air Conditioning Standards. President Shears then announced the creation of a new chapter in Manitoba, with headquarters at Winnipeg. H. H. Angus moved that the Secretary of the Ontario Chapter write the Manitoba Chapter congratulating them and wishing them every success. The motion was seconded by Mr. Maddux and carried.

Secy. H. R. Roth read the minutes of the two preceding meetings, which were accepted as read.

President Shears read a report of the University of Toronto Prize Committee and appointed a committee to act during the coming year on this matter. The committee consisted of: W. R. Blackhall, *Chairman;* H. H. Angus and E. H. Gurney.

President Shears appointed a committee to organize an Ontario Chapter party to attend the Annual Meeting of the Society in Chicago in January. The committee consisted of: W. P. Boddington, *Chairman;* H. B. Jenney, Thomas McDonald and A. G. Ritchie.

Mr. Boddington extended a cordial welcome to the guests of the evening before the meeting adjourned.

St. Louis

December 4, 1935. Thirty members and guests, including many members of the local section of the *A.S.R.E.*, attended the meeting which was held at Garavelli's with Pres. J. W. Cooper presiding.

Minutes of the October and November meetings were read and approved.

Secy. A. L. Walters read correspondence, including Pres. John Howatt's monthly letter and a letter from A. A. Langsdorf on behalf of the *American Association for the Advancement of Science* and associated societies, urging members of the Chapter to attend the Annual Science Exhibition which will be held in St. Louis, December 30 to January 4.

The Secretary announced the receipt of three new applications for membership: C. F. Boester, W. A. Chapman, Jr., and C. P. Smith.

R. J. Tenkonohy, Chairman of the Chapter's Committee on Constitutional Amendments, presented a proposed amendment, whereupon it was moved by Mr. Tenkonohy that the amendment be adopted. The motion was seconded by E. E. Carlson and carried.

President Cooper reviewed the activities of his administration during the year.

Paul Sodemann presented the nominations for new officers, after which the Chair called for nominations from the floor.

It was moved by J. E. Manahan, and seconded by E. A. White, that nominations be closed. The motion was carried.

It was moved by Mr. Sodemann, and seconded by Mr. Manahan, that the nominees be unanimously elected to the various offices for which they were selected and the motion was carried. The officers elected are as follows: *President*, C. R. Davis; *First Vice-President*, George Myers; *Second Vice-President*, A. L. Walters; *Secretary*, R. J. Tenkonohy; *Treasurer*, E. E. Carlson; *Board of Governors*, J. W. Cooper, D. J. Fagin, C. E. Hartwein and G. B. Rodenheiser.

President Cooper then spoke of his appreciation of the honor of serving the Chapter as President and thanked the members for their cooperation during his term. Mr. Cooper called upon the newly elected president, C. R. Davis, who accepted his election and said that he hoped he would make as good a president with two good legs as his predecessor had with only one. Mr. Davis then called upon the other newly elected officers who in turn expressed their appreciation of their election.

It was moved by A. L. Walters, and seconded by Mr. Carlson, that Mr. Tenkonohy be named the Chapter's Representative on the Society's Nominating Committee, and that he also be named as the official representative of the Chapter to the next Annual Meeting, to whom the Society's travelling allowance should be paid. The motion was carried.

It was moved by President Davis, and seconded by Mr. Sodemann, that J. W. Cooper be named as alternate member on the Society's Nominating Committee. The motion was carried.

There being no further business, the meeting was turned over to George Myers, Chairman of the Program Committee, who introduced Mr. Sodemann as the speaker of the evening. Mr. Sodemann very ably read and discussed the paper on Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet.

The presentation of the paper was followed by considerable discussion. After a rising vote of thanks, the meeting was adjourned.

Western Michigan

December 9, 1935. Twenty-seven members and guests attended the December meeting of the Western Michigan Chapter held in the English Room of the Hotel Rowe, Grand Rapids.

It was voted to hold the January meeting in Battle Creek at one of the food manufacturing plants, if suitable arrangements can be made, and it was further decided to issue invitations to ladies to attend this meeting as it was thought that an inspection trip would be of interest to them.

Prof. L. G. Miller, Engineering Department of Michigan State College, who is Vice-President of the Western Michigan Chapter, gave an outline of the paper Comfort Standards for Summer Air Conditioning. Professor Miller presented his topic in a very interesting manner as was indicated by the discussion following.

J. H. Van Alsburg was appointed as representative from the Western Michigan Chapter to attend the Society's Annual Meeting in Chicago.

After the business session, S. H. Downs received many congratulations on his nomination as a member of the A.S.H.V.E. Council.

November 11, 1935. At the November meeting held in the Hotel Rowe, Grand Rapids, 25 members and guests were present.

Pres. P. O. Wierenga named W. W. Bradfield, S. H. Downs, K. L. Ziesse, E. I. Adams, and L. G. Miller as a committee to investigate the feasibility of the Chapter taking steps to establish an air conditioning code.

C. A. Storch gave an interesting talk on Temperature Control, and showed three reels of moving pictures illustrating systems of control and operation. According to Secy. J. J. Troske, the evening was very instructive to those who attended and the meeting adjourned at 10:30 p. m.

Southern California

December 10, 1935. The regular meeting of the Southern California Chapter was held at the Rosslyn Hotel, Tuesday noon, when 39 members and guests were present.

A short business meeeting was held at the conclusion of the luncheon, and Pres. Leo Hungerford urged that continued efforts be made to increase the number of affiliate members.

E. H. Kendall moved that Past President W. E. Barnum and President Hungerford be nominated as delegate and alternate to the 42nd Annual Meeting of the Society in Chicago to be held during the week of January 27-31. The motion was seconded and unanimously adopted.

The feature of the meeting was a talk by P. J. Washburn, acoustical engineer, New York, N. Y. The speaker discussed the subject of Acoustical Treatment and Sound Control, with particular reference to air conditioning systems and isolation of machinery noise and vibrations. The members and guests present evidenced much interest in Mr. Washburn's talk and the able manner in which it was presented.

According to Secy. H. M. Hendrickson the meeting adjourned at 2:15 p. m.

Washington, D. C.

November 18, 1935. A meeting of the Washington, D. C. Chapter was held at the Harrington Hotel, Washington, D. C. Forty-one members and prospective members were present for dinner at 6:30 p. m.

Pres. W. A. Danielson called the meeting to order at 8:30, when 57 members and guests were present. The minutes of the preceding meeting were read and approved.

President Danielson read a letter from Pres. John Howatt, Chicago, Ill.

Colonel Danielson then announced that it was in order to appoint a committee to nominate officers for the local Chapter for the year 1936. E. V. Fineran moved that the present officers serve and this motion was seconded by A. E. Beitzell and was unanimously carried.

President Danielson then introduced W. L. Fleisher, consulting engineer, New York, N. Y., and a member of the Committee on Research of the A.S.H.V.E., who delivered a very interesting paper on Comfort Standards for Summer Air Conditioning, prepared by the Society's Research Laboratory. Following the paper, discussions were given by R. B. Crawford, E. V. Fineran, Mr. Crosby, H. H. Downes, A. E. Beitzell and L. S. Ourusoff.

The meeting adjourned at 11:10 p. m., as reported by Secy. M. D. Kiczales.

Revision of Rules

At the Council Meeting in New York, Dec. 2, 1935, the following Revision of Rules was adopted in accordance with the provisions of Art. B I, Section 9, of the Society's By-Laws:

Article R-XI—Section 1: The Secretary shall receive all bills against the Society and shall check and if correct approve for payment all items when covered by the Budget, or by special action of the Council and emergency expenditures approved in writing by the Chairman of the Finance Committee. A summary of these accounts shall be made at least every 30 days on a form approved by the Council and a copy shall be submitted to the members of the Finance Committee, the President and Treasurer of the Society. A check for the total amount of the bills listed in the summary shall be drawn on the Treasurer's account and when signed by the Treasurer and countersigned by the President of the Society, shall be deposited to the credit of the American Society of Heating and Ventilating Engineers in the special Secretary's account. The Secretary shall draw against this amount in settlement of all approved expenditures.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 43 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by January 15, 1936, these candidates will be balloted upon by the council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ANSPACHER, T. H., Br. Mgr., Buffalo Forge Co., Kansas City, Mo.	N. W. Downes L. R. Chase	F. J. Dean, Jr. G. L. Bliss
BARNES, HERBERT, Plbg. & Htg. Contractor, Hamilton, Ont., Can.	G. H. Hopper W. R. Blackhall	H. S. Moore O. L. Maddux
BLUMENTHAL, M. I., Engrg. Instructor, National Schools, Los Angeles, Calif.	E. W. Riesbeck (*Non-Member*) H. A. Lewis (*Non-Member*)	E. F. Keyes (*Non-Member*) John Wyllie, Jr. (*A.S.R.E.*)
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WILSON, R. A., Sales Engr., Minneapolis-Honeywell Reg. Co., Cleveland, Ohio.	L. T. Avery Philip Cohen	W. D. Graham F. R. Dickenson

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

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HILL, H. H., Field Engr., Frigidaire Corp., Dayton, Ohio.
HOLMES, A. D., Sales Engr., Plumbers Supply Co., Tulsa, Okla.
PAYNE, R. E., Draftsman, E. I. Du Pont de Nemours, Wilmington, Del.
WILSON, ANDREW, Estimator and Supt. of Installations, Montgomery Ward Co., Jamaica, L. I., N. Y.

ASSOCIATES

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EDELMAN, B. P., Sales Dept., U. S. Air Cond. Corp., Minneapolis, Minn.
HEWETT, J. B., Engrg. Mgr., Hudson Air Cond. Corp., Washington, D. C.
KRENZ, A. S., Sales Mgr., Krenz & Co., Milwaukee, Wisc.
LITTLE, K. B., Repr., The Brownell Co., Cincinnati, Ohio.
THOMPSON, E. F., Draftsman, E. I. Du Pont de Nemours Co., Atglen, Pa.
WHITTAKER, W. K., Htg. & Vtg. Maintenance, Irving Trust Co., Bldg., Flushing, L. I., N. Y.

JUNIORS

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CALL, JOSEPH, Air. Cond. Engr., J. J. Pocock, Philadelphia, Pa.
ESCHENBACH, S. P., Salesman, American Blower Corp., Buffalo, N. Y.
GRIMES, F. M., Engr., T. H. Urdahl, Washington, D. C.
MOZLEY, R. G., Student, G. E. Air Cond. Inst., New York, N. Y.
MULLEN, T. J., Jr., Sales Engr., B. F. Sturtevant Co., Washington, D. C.
STEENECK, K. C., Htg. Engr., John G. Kelly Co., New York, N. Y.

STUDENT

LUDERS, R. H., Student, University of Illinois, Urbana, Ill.

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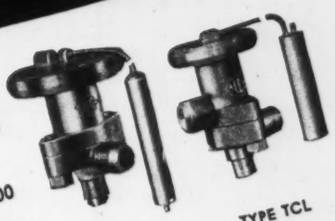
Available with either S. A. E. Male Flare or solder line connections in all practical sizes



TYPE TL TYPE TCL
Actual Size—2⅝ in. x 3⅛ in.

Maximum tons refrigeration capacity at 60-lb. pressure difference across valve				
Constr. No.	00	0	1	2
CH 3 CL	1.2	2.6	5.6	8.4
SO 2	1.0	2.1	4.7	7.4
F 12	.6	1.3	2.9	4.4

Types TAL and TDL THERMO VALVES

Type TAL with Internal Superheat Adjustment. Net weight, 2 lbs. ..... List Price $15.00

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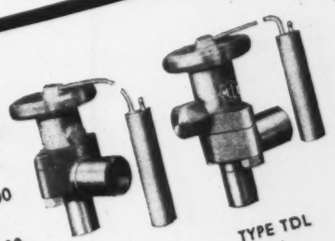
Available only with solder line connection, but will accommodate a wide selection of tubing sizes by the use of standard solder type coupling



TYPE TAL TYPE TDL
Actual Size—2⅝ in. x 4½ in.

Maximum tons Refrigeration capacity at 60-lb. pressure difference across valve					
Constr. No.	00	0	1	2	3
CH 3 CL	1.2	2.6	5.6	8.4	12.3
F 12	.6	1.3	2.9	4.4	6.2

Types TBL and TEL THERMO VALVES

Type TBL with Internal Superheat Adjustment. Net weight, 2½ lbs. ..... List Price $30.00

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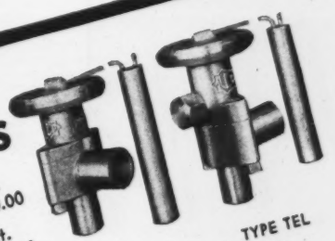

TYPE TBL TYPE TEL
Actual Size—3 in. x 4¾ in.

Maximum tons refrigeration capacity at 60-lb. pressure difference across valve			
Constr. No.	4	5	6
CH 3 CL	15.2	19.5	23.9
F 12	8.7	11.4	14.0

● Ask for technical Bulletin No. 144-C to get complete description of Series "T" Thermo Valves

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Magnetic Valves • Float Switches for Usual Refrigerants

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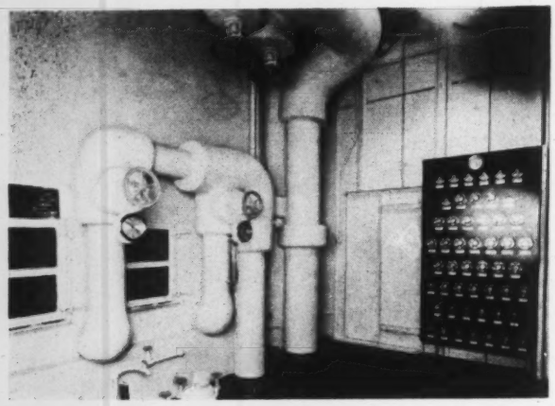

Pipe lines insulated with "Jointite", Canvas finish.

Air Conditioning efficiency **is increased when low temperature lines are protected with "Jointite" Cork Insulation. "Jointite" does not wear out, settle, rot or warp. Its indispensable service in the Refrigeration field is one of its many recommendations. "Jointite" is produced in special thicknesses for Air Conditioning requirements. Write for complete details, including specification data. Ask us, also, about Mundet Cork Isolation Mats for reducing machine vibration.**

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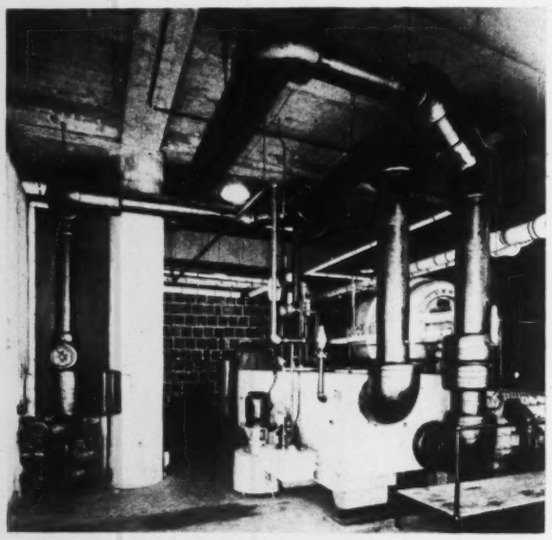

Air Conditioning Plant in large department store. Pipes insulated with "Jointite" cork covering, mineral rubber finish.

Supplement to The Chicago Air Conditioning Standards of October, 1935

These notes are explanatory and suggestive. They are indexed to correspond with the section numbers in The Chicago Air Conditioning Standards of October, 1935.*

DEFINITIONS

Coefficient of Heat Transmission (Symbol-U)—The amount of heat expressed in Btu transmitted in one hour per square foot of area per degree F difference in temperature from the air on one side of a barrier to the air on the opposite side.

Comfort Zone—The range of air environmental conditions which, due to temperature, air motion and moisture content, provides comfortable conditions to fifty per cent or more adults. (This has been determined experimentally, and usually is indicated on a psychrometric chart.)

Compressor—A device used for reducing the volume of a gas by the application of pressure.

Condenser—A device used for liquefying gases by the removal of heat.

Conductance (Symbol-C)—The amount of heat (Btu) transmitted from surface to surface in one hour through one square foot of a material or construction, whatever its thickness, when the temperature difference is 1 F between the two surfaces.

Conductivity (Symbol-k)—The amount of heat expressed in Btu per hour, per square foot in area per inch thickness per degree F difference in temperature, transmitted through a barrier of homogeneous material from the air on one side of the barrier to the air on the opposite side of the barrier.

Convection—The process of transferring heat by the circulation of a gas or liquid from a warm surface to a cooler surface.

Convector—A device which transmits heat by means of convection.

Degree Day—A unit based on the difference between an assumed temperature base and the daily average temperature. [The standard degree day base temperature is 65 F. For example, if the average temperature for a day (24 hours) were 40 F for that particular day there would be 65 — 40 = 25 degree days. The degree day figure is useful in estimating the seasonal heat demand. There are degree day tables available for the major cities for comfort heating, industrial heating and for other purposes depending upon the base temperature used. If a certain locality has 5,000 degree days and the rate of heating is 200,000 Btuh when the temperature range is 0 F to 70 F then: 200,000 (Btuh) × 24 (hours) × 5,000 (degree days) — 70 = Btu per season.]

Direct Expansion—The process of expanding a refrigerant in a container that is placed in the medium from which heat is to be extracted.

Evaporator—A container in which a refrigerant is expanded to absorb heat from the medium to be cooled.

Humidity—The moisture content of air.

Absolute Humidity—The amount of water vapor expressed in weight per unit volume at a given temperature.

Specific Humidity—The weight of moisture expressed in pounds carried by one pound of dry air.

Relative Humidity—The ratio of the weight of water vapor in a given space as compared to the weight of water vapor which the same space contains when filled with saturated vapor at the same temperature.

Infiltration—The passage of unconditioned air into enclosed spaces through various openings.

*See Heating, Piping and Air Conditioning, November, 1935, pp. 539-540.

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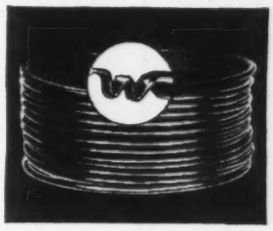
SEAMLESS COPPER TUBING

FOR

AIR CONDITIONING OIL BURNERS AND HEATING



EXTRUDED from 99.9% pure deoxidized copper, Wolverine Copper Tubing is strong, close grained and has the characteristic Wolverine Mirror Finish. The dimensional accuracy attained in this process assures perfect joints with all soldered and flared type fittings.

Wolverine deoxidized water tubing is a favorite for air conditioning and space cooling installations. It is guaranteed to conform to A.S.T.M. and Government specifications in types "K", "L" and "M". It is furnished in both hard and soft tempers.

All Wolverine dehydrated tubing is solder sealed with the Wolverine W for refrigeration work. It is made in a uniform soft temper and meets A.S.T.M. Specification B-68-33 . . . furnished both plain and tin plated.

The installer may obtain Wolverine refrigeration tubing in securely wrapped coils . . . a convenient compact package which adequately protects the tubing and keeps it perfectly clean and bright until it is used. The size and length are designated on the outside of each package.

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Guessing is unreliable. Often dangerous. Whether you are conditioning air, heating a building, controlling processing or checking humidity, you should know what results you are securing. Bristol's instruments will tell you. Write for the particular bulletins in which you are interested. Also, get a copy of Bulletin No. 435 describing the complete Bristol's line.

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Flow Meter

For indicating, recording, controlling, integrating flow of steam, air, gases, liquids. A rugged, reasonably-priced mechanical flow meter that under severe field conditions can be counted on to give precision measurement. Compensates for line pressure, records rate of flow, line pressure and temperature. Bulletin 425.

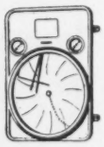
Metameter

For telemetering pressure, liquid level, temperature, motion. Twelve-inch chart at headquarters records instantly every fluctuation in steam pressure, voltage, or level occurring a few feet or a thousand or more miles away. Simple two-wire circuit or existing telephone line. Bulletin 424.

Electric Indicating Thermometer

For taking temperatures at any number of distant places. Indicates temperature with precision accuracy. The measuring elements or resistance bulbs are interchangeable. Bulletin 997.

Full Floating Free Vane Air-Operated Recorder Controller



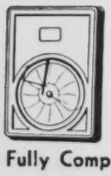
Device utilized for effecting temperature or pressure control floats from one position to another. It does no mechanical work. It encounters no resistance or friction. Indications are accurate There is no distortion. Catalog 4001.

Synchro Automatic Control Valve

Diaphragm operated, V port balanced type. For a given air pressure on the diaphragm top, position of the valve opening is the same, whether pressures are rising or falling. There is no friction loss. Response is instantaneous. Bulletin 938.

Thermo-Humidigraph

Or direct reading temperature and relative humidity recorder. Eliminates calculation and use of humidity tables. Eliminates personal errors. No water or fan required. Accurate below freezing temperature. Light portable case of corrosion-resisting materials. Bulle tin 413.

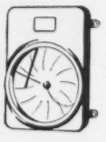


Recording Absolute Pressure Gauge

As easy to read as a clock. Furnishes continuous 24 hour record of absolute pressure automatically corrected for barometric variations and temperature changes. Supplied for ranges as low as 0 to 50 millimeters head of mercury column. Bulletin 401.

Fully Compensated Liquid-Filled Thermometer

Charts accurately the temperatures to which the sensitive bulb is subjected. Neither a long length of connecting tubing nor disturbing temperature conditions along the tubing can impair its precision performance. Bulletin 1002.



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humidity of 35 per cent or more is maintained. These cold surfaces include the windows, when single glass is used, and the metal framework of certain types of windows. To serve as an index as to what may be expected with single and double windows with varying outside temperatures, and certain indoor humidities, the designer is referred to the *A.S.H.V.E. Guide*. The designer of air conditioning equipment should, at all times, provide means for the prevention or disposal of condensation from the conditioned air, within the occupied spaces.

SECTION 6.

Minimum Design Temperatures and Humidities for Cooling—This standard involves two frequently encountered conditions. A plant which answers one of these conditions may fail to meet the other. Therefore, the designer, in order properly to protect the owner, should be assured that the plant shall have capacity to meet both conditions.

SECTION 7.

Infiltration and Leakage—In the practical application of the information contained in the *A.S.H.V.E. Guide*, simplified data based upon the same, approved and published by an accredited organization, if used in calculating values for design purposes shall be considered as fufilling the requirements of the Standards. (See last paragraph.)

SECTION 8.

Design Load Calculations—

(a) 1—Suggested reference, see last paragraph.

(a) 2—See Section 7.

(b) 1—Suggested reference, see last paragraph.

(b) 3—Suggested reference, see last paragraph.

(b) 4—For convenience, a table giving the approximate amount of heat in Btu per hour, dissipated by human beings at 70 F, is listed below:

Activity	*Sensible*	*Latent*	*Total*
At rest	310	105	415
Light work	290	248	538
Moderate work	400	400	800
Heavy work	650	850	1500
Dancing	470	530	1000

To show the variation in moisture content in the relation of changes in dry bulb temperature, a table follows:

Room Dry Bulb Temp., F	*Sensible Heat Btu Per Min.*	*Latent Heat Btu Per Min.*	*Total Heat Btu Per Min.*	*Grains Moisture Per Min.*
70	5.12	1.58	6.70	10.90
75	4.50	2.15	6.65	14.80
80	3.74	2.86	6.60	19.70

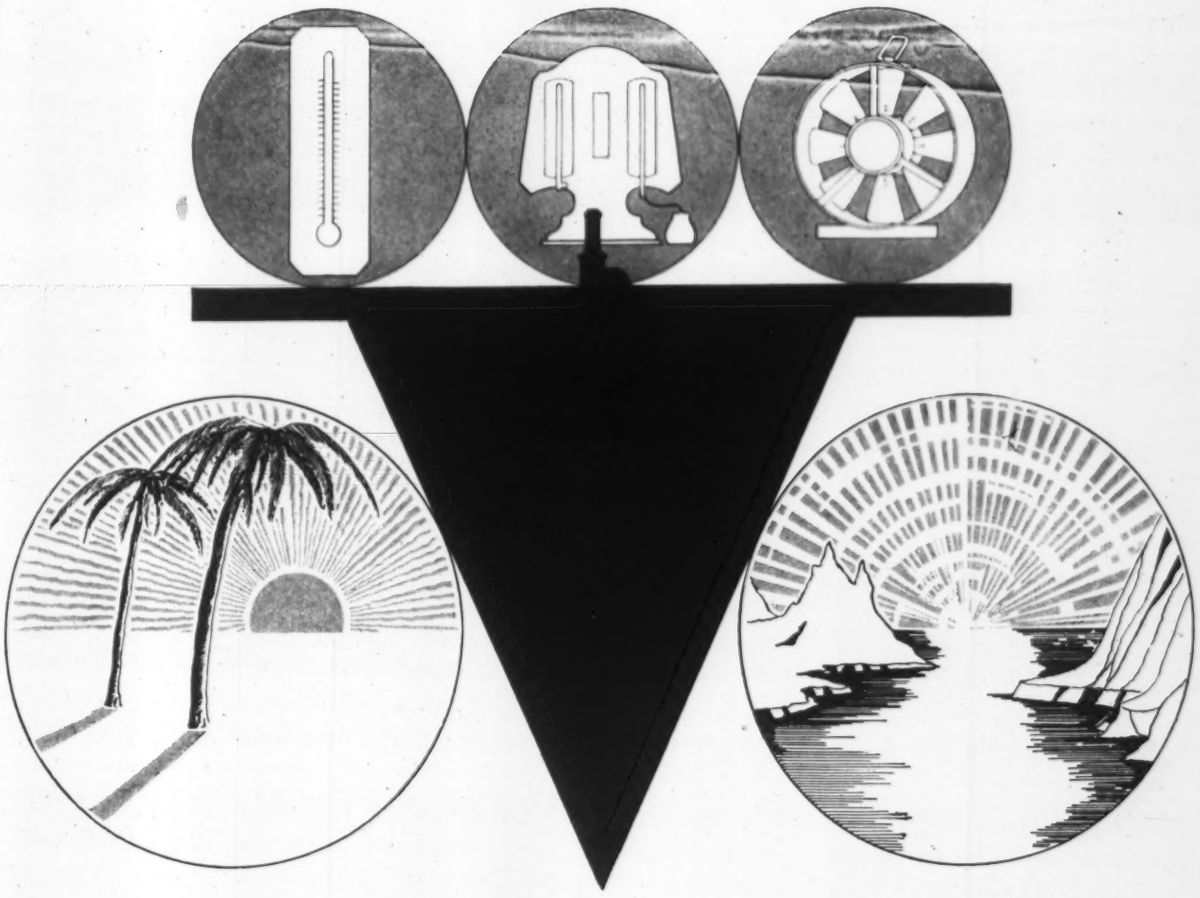
(b) 5—Heat from appliances, illumination, small motors and similar equipment, may be determined from tables and data approved and published by an accredited organization. A properly determined load factor may be used in these calculations.

SECTION 9.

Design Allowance for Shading from Sunshine—A letter to the owner indicating that a reduction in capacity has been made, due to an allowance for shading, shall be considered a proper notification.

SECTION 10.

Design Air Quantity—(a) A fundamental in every design of air conditioning equipment is that the minimum legal requirements shall be fulfilled regardless of the difficulties encountered in other directions. Therefore, when designing for capacities for air conditioning systems, it is suggested that the designer should present a sketch of the proposed design to the Ventilation Plan Examiner of the Chicago Board of Health, for an analysis with respect to the requirements of the ordinance. Due to the range of requirements contained in the license ordinances, nuisance regulations and miscellaneous control measures, the designer should have intimate knowledge of the true use of the space to be conditioned, and this use is to be expressed in the terms used in the ordinance so that there will be no difficulty in citing the requirements of the proper sections of the ordinance relating to the establishment in question.



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Parted forever are Nature's climatic extremes from man's life indoors at work and in recreation. Reborn are the arts, professions, trades and industries embraced by modern heating, ventilation and air conditioning.

"The great industry of the future" has become the great industry of the present. Civilization is paying willing tribute to those whose knowledge, initiative and energy are promoting the world's health, comfort and efficiency.

What will be your share of the rich rewards? The answer is—what you make it. To be sure that you will be in line for the major prizes, one step is essential. You must be and keep informed! You must know the latest and the approved methods, materials, equipment, instruments, tools and supplies—and where to get them.

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FOURTH INTERNATIONAL HEATING & VENTILATING EXPOSITION
CHICAGO-ILL
January 27-31-1936

Under the auspices of the American Society of Heating & Ventilating Engineers

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THE AIR CONDITIONING EXPOSITION

FOURTH INTERNATIONAL HEATING & VENTILATING EXPOSITION

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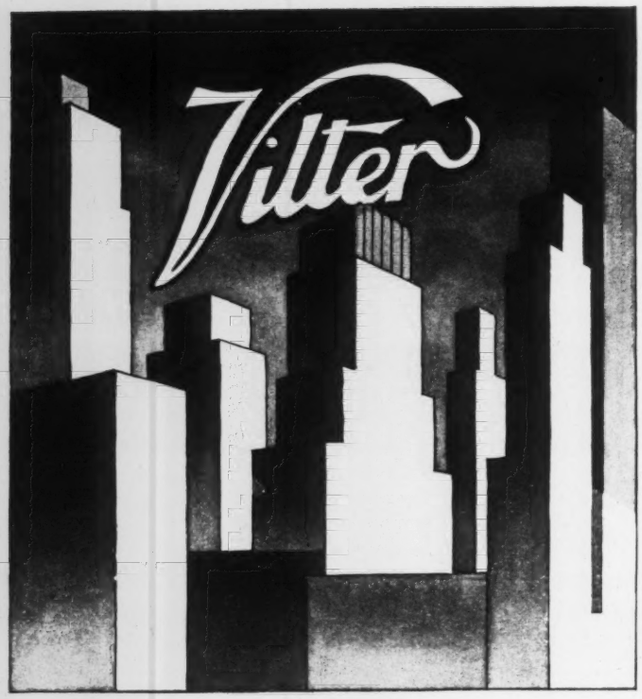

Air Conditioning

for Today...and the Tomorrows!

That same spirit of pioneering which has carried Vilter to the very pinnacle of fame in the world of industrial refrigeration is very definitely reflected in its achievements in the air conditioning field.

With new ideas, new technical developments and new ambitions, the proud traditions of the Vilter organization have carried its works to new heights.

Vilter is today in position to offer a service far beyond the mechanical installation of standard units. Rather, it offers the expert and experienced cooperation of an engineering organization thoroughly grounded in every diversified phase of modern air conditioning practice.

Prospective purchasers, architects and engineers, in considering their air conditioning problems, will do well to consult this old established progressive organization.

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"SINCE 1867"
2148 South First Street
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REPRESENTATIVES IN PRINCIPAL CITIES

(b) The Chicago Municipal Code for 1931 does not require air cooling. It does require that any system of ventilation such as windows or other natural facilities, to be considered as fulfilling the requirements of the ordinances must, at all times, be under the control of the persons in the air conditioned spaces. It follows that in an air conditioning design only the mechanical ventilation requirements of the ordinance can be the basis of design since air conditioning systems will not function properly if natural facilities for ventilating purposes are used. The Chicago Municipal Code for 1931 has not fixed 10 cfm of air from the outside as a minimum. Wherever the ordinance requirements are expressed in cubic feet of air per minute per person it is in excess of 10 cfm. Therefore, wherever 10 cfm is used in design it must be in those types of establishments which are not regulated by ordinance with reference to ventilation.

SECTION 11.

Design Duct Capacity—Self-explanatory.

SECTION 12.

Design Air Distribution—Self-explanatory.

SECTION 13.

Refrigerating Apparatus and Refrigerants—(a) Self-explanatory.

(b) The fundamental design of refrigerating systems for air conditioning purposes requires that the designer should have an intimate knowledge of the regulations contained in Sections 3474 to 3486, inclusive, of the Chicago Municipal Code for 1931, under the jurisdiction of the Department for the Inspection of Steam Boilers, Unfired Pressure Vessels and Cooling Plants. This part of the Chicago Air Conditioning Standards is closely related to the provisions contained in Sections 3481 to 3483, inclusive, of the above mentioned city ordinances. The location of the valves is specifically mentioned in these sections.

(c-d) Self-explanatory. (Except as in the case of (b), refer to the Chicago Municipal Code for 1931.)

(e) This standard is based upon the requirement of the Board of Health, as quoted below:

"In every refrigerating system in which dichlorodifluoromethane is used, and a part of such system containing the refrigerant is placed into a ventilating system in the air to be used for ventilating purposes, there shall be provided such means as will produce a signal sufficient to attract the attention of the person or persons responsible for the operation of such equipment in case at any time ten pounds of the refrigerant should escape from the refrigerating system."

The city ordinances deal entirely with the public interest and safety aspect of refrigeration systems. These Standards, while in accord with the ordinances, should, in addition, afford the owner a satisfactory system with respect to operation and reasonable maintenance. Therefore, precautionary measures should be taken as follows:

(1) Welded steel pipe should be seamless, pickled and dehydrated.

(2) Copper pipe and tubing, welded joints, headers and built-up sections should be cleaned with carbon tetrachloride or other suitable cleaner, to remove all scale, rust, dirt, solder, paste and filings.

(3) All flared joints should have full flaring, be smooth and free from cracks and burrs.

(4) Tests for refrigeration systems shall be conducted in accordance with Section 3484 of the Chicago Municipal Code for 1931.

(5) All joints and connections should be separately investigated with the aid of proper equipment to detect the escape of the refrigerant.

(6) Refrigerating compressors should be provided with high and low pressure gauges.

(7) Systems having multiple evaporators should be provided with gauges for each evaporator, so that the expansion valves can be properly adjusted.

(8) Thermometers should be provided on condenser inlet

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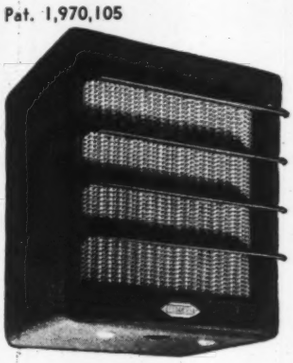

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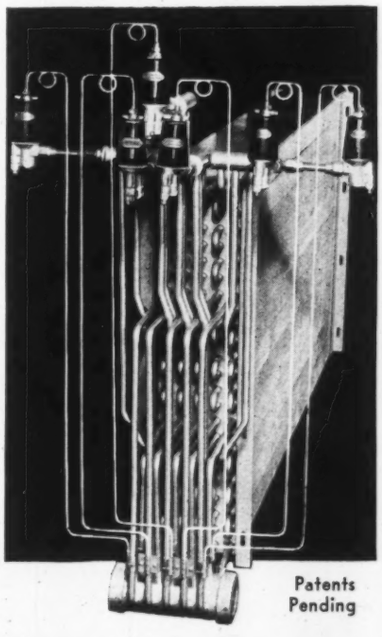

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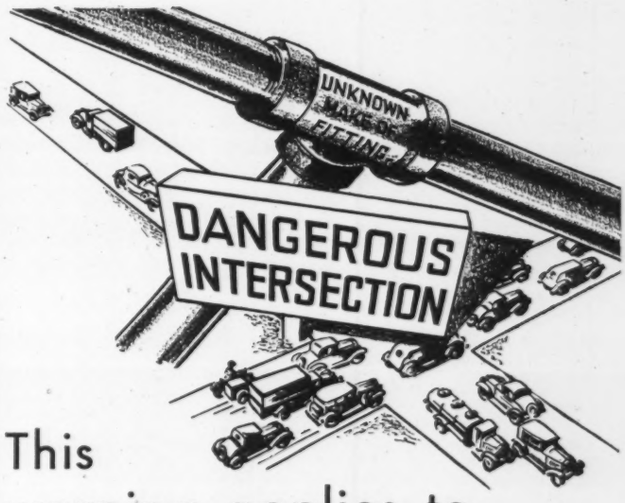

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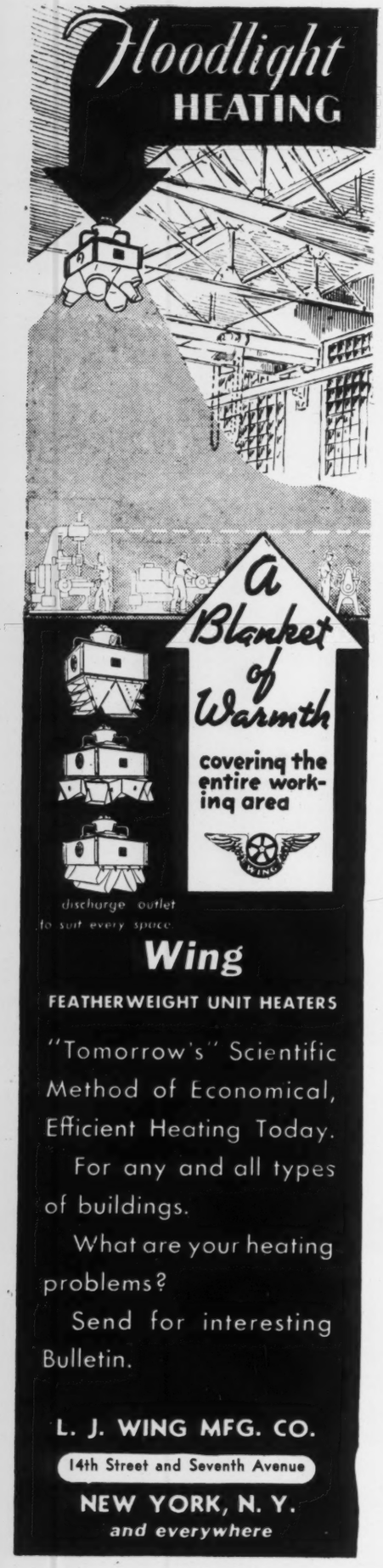


and outlet lines, as well as on other water inlet and outlet lines used for cooling purposes.

(9) Electric controls, motors and starters shall conform to the requirements contained in Chapter 32 of the Chicago Municipal Code for 1931, under the jurisdiction of the Department of Electrical Inspection and also should meet the requirements of the Commonwealth Edison Company.

(10) Unions or flanged connections should be provided to facilitate removal of automatic control and similar devices and valved bypass arrangements must be made so as to permit operation of the system while such devices are being inspected or repaired.

SECTION 14.

Details of Construction—Self-explanatory.

SECTION 15.

Heat Transfer Apparatus—(a) This provision relates to the requirements of the Chicago Board of Health that all connections to the sewer shall be of such design that in the event the water supply system is drained, that sewage is not syphoned into this system. This is generally accomplished by interposing an air gap of 2 to 3 inches between the sewer and the end of the discharge pipe from the condenser.

(b), (c) and (d)—Self-explanatory.

SECTION 16.

Noise Control—The quantitative measurement of noise is recognized as a complex and difficult problem. For a more intimate knowledge of this subject and a better understanding as to the application of this section, it is suggested that the chapter on "Sound Control" in the *A.S.H.V.E. Guide* be given detailed consideration.

SECTION 17.

Insulation—The coefficient of heat transmission (U) of the insulation should be such that the heat transfer will be low enough so as to prevent the outer surface of the insulating material from attaining a temperature colder than the dew point temperature of the air surrounding it.

The relationship of dew point temperature for corresponding wet and dry bulb temperature may be obtained from a psychrometric chart.

The coefficient of heat transmission for various materials may be obtained from the *A.S.H.V.E. Guide*.

If the insulation of cool surfaces fails to prevent contact of the moist surrounding air with the cool surfaces, the condensation out of the air will moisten the insulation and may destroy its efficiency and shorten its life.

SECTION 18.

Guaranty—Self-explanatory.

GENERAL INFORMATION

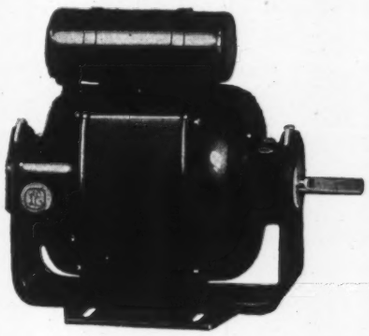
Permits—An air conditioning system invariably contains the elements that bring these systems under the jurisdiction of five municipal departments of the City of Chicago. These departments are: (1) Board of Health; (2) Boiler Department; (3) Building Department; (4) Electrical Department; (5) Fire Prevention Bureau.

Other departments may also have jurisdiction. The contractor, before proceeding with the installation of an air conditioning system, should be properly protected by obtaining all of the required permits. When in doubt, information respecting legal requirements and permit fees may be obtained by consulting the various departments.

Pamphlets and Reprints Relating to City Requirements—The Chicago Municipal Sanitary Code of 1931 has not been reprinted; therefore information required to conform with this Code can only be obtained by consulting the revised Chicago Municipal Code of 1931 or by applying to the Board of Health for such information.

The ordinances regulating refrigeration have been mimeographed and a copy of same may be obtained on request from the Department for the Inspection of Steam Boilers, Unfired Pressure Vessels, and Cooling Plants. For other city regulations, the respective municipal department should be consulted.

The tabulation below contains the names of organizations that have prepared and published certain data which may be found helpful when used in calculations for designing air conditioning systems to conform with The Chicago Air Conditioning Standards:—*American Society of Heating and Ventilating Engineers—Guide; American Society of Refrigerating Engineers—Data Book; Chicago Master Steamfitters' Association; Illinois Society of Architects—Hand Book.*



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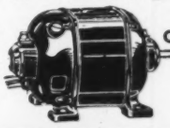

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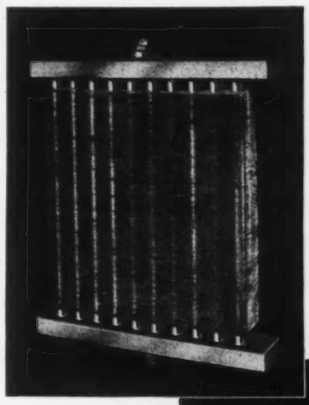
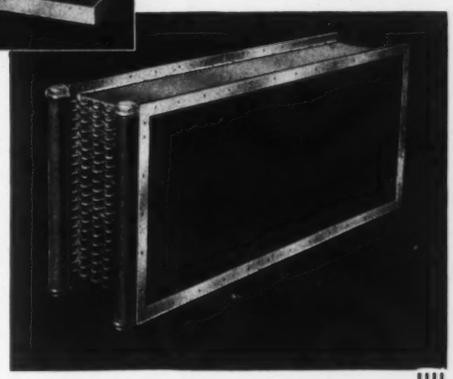


WHEN AND AS YOU WANT THEM

20" x 20" Face
2 Rows Deep
All Steel

30" x 72" Face
12 Rows Deep
All Copper



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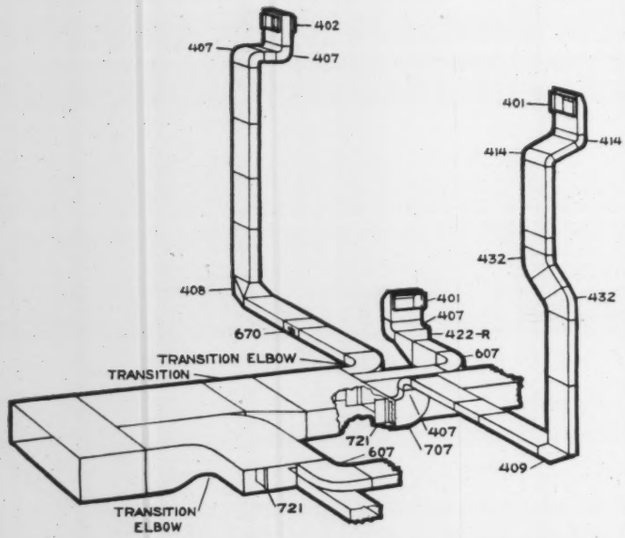

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Everything required to make a complete summer and winter air conditioning installation. Wall stack, stackhead and foot pieces made with special Moncrief lock joints. Moncrief Combination Outlet presents many advantages, including eliminating necessity of installing volume dampers in ducts. The product of thirty-eight years experience in the manufacture of pipe and fittings.

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Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 185 . . .

New Heat Transfer Surface

No. 630—New development in light weight, copper tube and fin heat transfer surface features use of two steam distributing tubes inside each of the regular condensing tubes of the surface. Within each finned condensing tube are two distributing tubes, the larger of which extends from the steam header approximately one-half the length of the heater, and is pierced with a number of small orifices through which steam is fed to the steam half of the finned tube. The smaller internal tube extends from the steam header to the return header, and for the half of its length which projects beyond the larger tube, it is pierced with similar orifices through which steam is fed to the return half of the finned tube. The openings from the steam header into the steam distributing tubes are metered to admit the proper relative proportions of steam to each half of the heater. This, together with correct spacing of the orifices, assures uniform steam distribution throughout the heater, regardless of the steam pressure or the quantity of steam supplied, according to the maker. With full line pressure, full heating capacity is secured; as the steam supply is throttled, the leaving air temperature is reduced, but the temperature of the air leaving the heater is uniform over the entire face area.—John J. Nesbitt, Inc., Holmesburg, Philadelphia, Pa.

Air Operated Regulator for Diaphragm Valve, Damper Motor Control

No. 631—New compressed air operated regulator designed for control of air temperatures (dry bulb, wet bulb, and dew point) and liquid temperatures employs the saturated vapor principle, but its adjustment dial has uniform temperature graduations; *i.e,* bunching of temperature graduations at one end of the range is eliminated.

The thermostatic bulb may be installed in the air or liquid at point where the temperature is to be controlled, while the adjusting dial and operating mechanism may be at a more convenient point, the two being permanently connected by armored flexible capillary tubing unaffected by temperature changes.

Furnished in three styles:—The regulator alone, combination of regulator with 4 in. diameter indicating dial thermometer, and in combination with 12¼ in. diameter recording thermometer making record on a 10 in. chart. Bulbs of seven different designs available for 0-100, 50-150, 100-200, or 150-250 F temperature ranges.

In conjunction with diaphragm valves or damper motors it is applicable to control of dry kiln temperature, varnish drying rooms, air washers, humidifying apparatus, chemical treatments, dyeing and bleaching machinery, and other processes involving the use of heating or cooling mediums.—Powers Regulator Co., 2720 Greenview Ave., Chicago, Ill.

Rotary Displacement Gas Meter

No. 632—New smaller size (2½x7 meter) extends range of sizes of rotary displacement meters. Built for line pressures up to 25 lb per sq in., normal capacity 5000 cu ft per hr, at 1 in. water gage differential, maintains commercial accuracy on loads ranging from 10 to 150 per cent of normal rating.

Meter is compact, measuring 22x14x15 in. Regularly supplied with base for foundation mounting, but can also be furnished with special bottom pipe plate permitting direct mount-

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In most cases it costs less to use Fretz-Moon Pipe—even though it is recognized as a product of highest quality and uniformity.

Figure it out for yourself. If the steel pipe you use is absolutely uniform—if every length is true to size, perfectly round, tightly welded, straight, accurately threaded, clean inside and outside and, in the case of galvanized finish, with a non-scaling, rust-resisting zinc alloy surface—if it bends, cuts and threads easily and is free from hard or burnt spots in the metal—then, obviously, it should cost less to install.

And that is why Fretz-Moon Pipe is less expensive to use—because it offers these advantages. Judge for yourself. Try it on your next job and note the difference.

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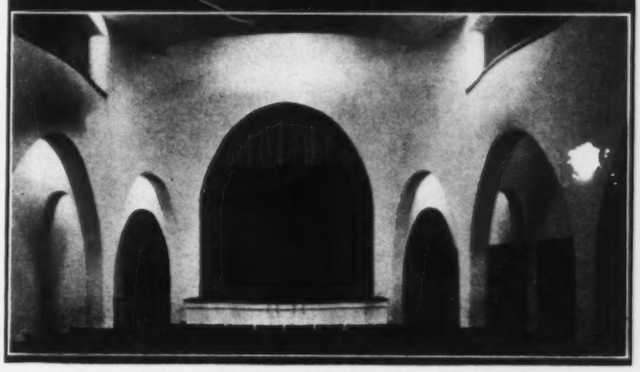

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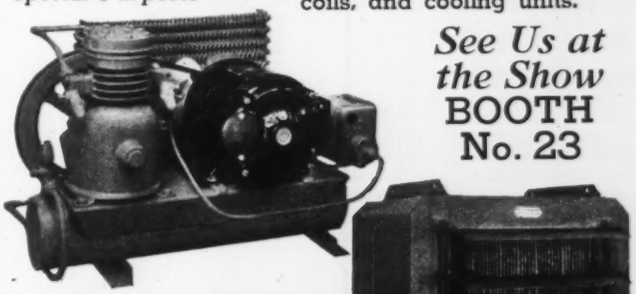

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Applicable to small gas plant operation, industrial and commercial gas consumer installations, low pressure natural gas wells and transmission lines, chemical processes, sewage gas measurement, or measuring gas engine fuel consumption.—Roots-Connersville Blower Corp., Connersville, Ind.

Refrigerating Units for Air Conditioning

No. 633—Two new "Freon" refrigerating units, designed especially for air conditioning and water cooling work, resemble in their general arrangement the standard ammonia refrigerating units which the manufacturer has been building for many years. The unit comprises an enclosed type compressor, driven through V belts by a motor mounted above the fly wheel; underneath the motor base is the condenser coil.

The 15 ton machine has three vertical cylinders and is driven by a 15 hp motor. The 20 ton unit has four cylinders arranged in a V pattern and is driven by a 20 hp motor. (Capacities given are based on a suction temperature of 40 F.) Both machines have cylinders of 4¼ in. bore by 4¼ in. stroke.

Condenser is a new type that gives extra cooling surface by nesting a number of small water tubes (instead of a single water tube) inside the large outer tube. The charge of "Freon" is carried in a receiver within the base, which is made of deep steel channels. The unit is complete with the necessary controls for full automatic operation, though it can be manually handled if desired.—Frick Co., Waynesboro, Pa.

New Line of Unit Heaters

No. 634—New line of unit heaters incorporates new principles of construction and modern cabinet designs. Construction provides a cross-flow circulation. The supply header and return header are integrally cast in one unit. The condenser is composed of a series of round copper tubes, formed into U shape, which extend in parallel rows from the header casting. The free ends of the U shaped tubes are supported by a steel spacer channel to permit free expansion and contraction without strain. Pipe connections are concealed within the back of the heater. —Perfex Radiator Co., Milwaukee, Wis.

Electrode for Welding 25-12 Stainless Steels

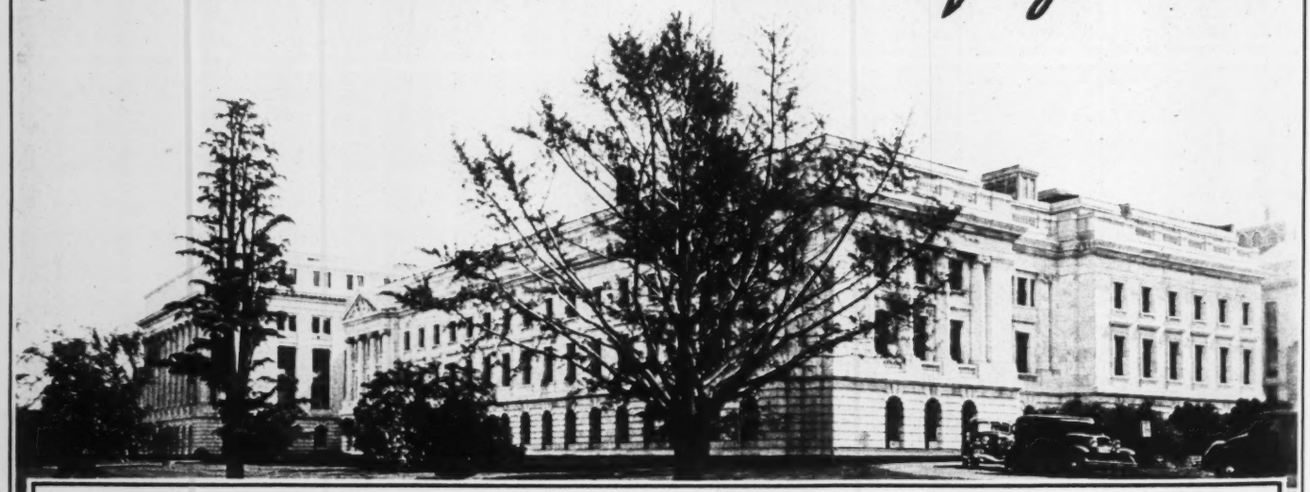
No. 635—New arc welding electrode ("Stainweld B") for welding the group of stainless steels belonging to the 25-12 variety announced last month. Because of its higher chrome content it is particularly advantageous for welding stainless clad steels, states the maker.

Provides weld metal of same characteristics as steel containing 25 per cent chromium and 12 per cent nickel. Weld metal has high corrosion resistance, high tensile strength and ductility. Electrode is heavily coated, utilizing shielded arc principle of producing welds free from oxides and nitrides, brittleness and porosity. Available in $\frac{3}{32}$ and $\frac{1}{8}$ in. sizes in 11 in. lengths.—The Lincoln Electric Co., Cleveland, Ohio.

Accessory for Hair-Line Valve Positioning

No. 636—New accessory for air operated control valves, the "Vernier Valvactor," developed to eliminate valve sticking and to assure hair-line valve positioning. This device enables throttling type air operated control instruments to make small gradual adjustments of the control valve position regardless of friction or hysteresis, and the air from the control instrument need change as little as ½ in. of water to cause a corrective positioning of the valve and force the stem to take a position within 1/1000th in. of the previous one, says the maker. Guarantees exact valve response where valve stem packing must be

Air Conditioned with Frick Refrigeration



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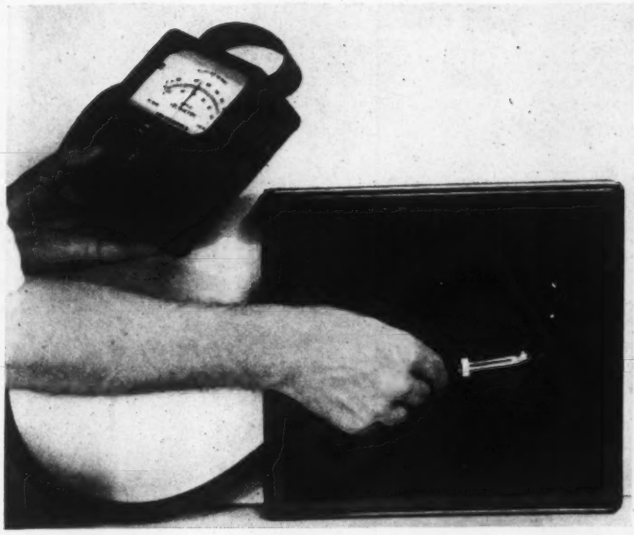

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No longer is it necessary to use expensive, complicated instruments and stop watches, or to make slow, mathematical calculations in order to obtain accurate air velocity readings.

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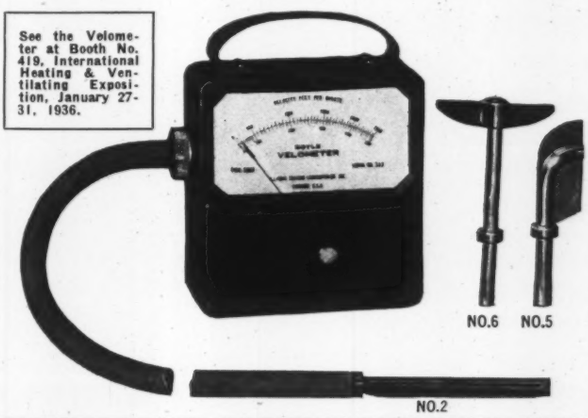

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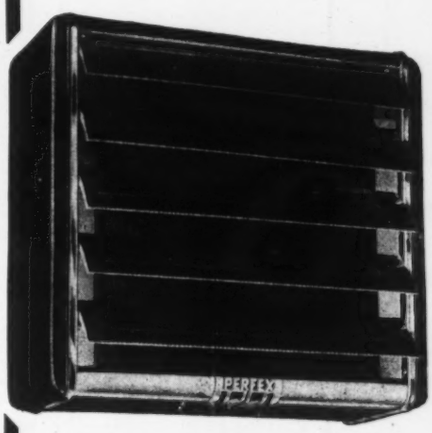
UNIT HEATERS



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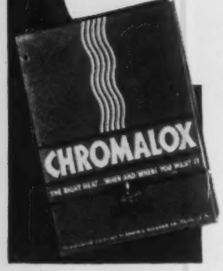

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very tight to prevent leakage; where fluids are viscous or contain solids; and friction is otherwise unavoidable or wherever there is danger of valve friction developing.

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New Low Alloy, High Tensile Steel

No. 637—New steel—"Hi-Steel"—is of the so-called low alloy, high tensile strength class. Minimum yield point is 60,000 lb per sq in. for gages lighter than ¼ in. and 55,000 lb in heavy gages. Minimum ultimate tensile strength is 70,000 lb per sq in., giving it a high elastic ratio. The elements used give this alloy a high degree of uniformity and physical characteristics as well as workability, states the manufacturer. Tests extending over a year's time show that it will bend, form, stamp, seam, and weld readily, and is highly resistant to corrosion. Supplied as sheets, strip, plates, bars, and structurals.—Inland Steel Co., First National Bank Bldg., Chicago, Ill.

Small Capacity Positive Displacement Pump

No. 638—New miniature triplex plunger reciprocating pump has been developed to handle fluids at a relatively high pressure and at the same time in small quantities.

Depending upon speed of pump, capacity may be varied from about 15 to 120 gal per hr. The power required by the pump is small, such that a ¼ hp motor will operate the pump at 60 gal per hr capacity and 200 lb pressure. It is a single acting plunger type having three cylinders of ¾ in. bore and ⅝ in. stroke with the plungers attached to cross-head guides which are driven by connecting rods from the crank shaft. Monel metal inlet valves are of poppet type, positively actuated through a cam and tappet mechanism and the outlet check valves are of the ball type with adjustable limited lift for high speed operation. Gears, crank shaft, connecting rods and cross-heads are entirely enclosed in crank case with splash lubrication. Crank case is of semi-steel. Cylinder head is corrosion resisting iron alloy, removable from the crank case to effect economical maintenance.

Pure water, water containing various percentages of alkaline compounds, fuel oils, mineral oils and various chemicals are readily handled, and it is adaptable to uses such as boiler feed, boiler compound injection, condensate returns, small hydraulic presses, fuel oil pumps for oil burners, pumping of chemicals, air conditioning apparatus and control apparatus.—Homestead Valve Mfg. Co., Coraopolis, Pa.

New Vibration Isolation Unit

No. 639—Strength, compactness and a high degree of vibration isolation are features of new type of "Seismo-Damper," built in sizes from 100 to 2500 lb capacity. With this damper the machine is directly supported by a "T" iron separated from a base of two angle irons by natural cork or other isolating material. The angle irons are firmly connected by bolts passing through the isolating materials and "T" iron, but not touching it.

Before installation these bolts are adjusted to produce a precompression of the isolating material to suit the machine load. Further adjustment can easily be made after installation. Where machine frame is light or must be supported at several points, the "T" iron can be extended to form a continuous support between two or more dampers to eliminate undue bending stresses in the machine frame.—Korfund Co., Inc., 48-15 32nd Pl., Long Island City, N. Y.

Clark-Sundh

An enclosed Primary Resistor Automatic Motor Starter with manual speed regulator for Fan duty. The panel complete with the resistor is hinged at the bottom so that it can be swung out for inspection. This permits installation close to building wall, without the usual clearance at the rear. Note the concealed door hinges and the resulting fine appearance of the closed cabinet. This is a sample of what we built for Rockefeller Center, New York.

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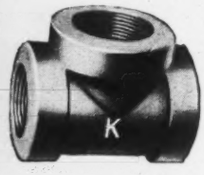

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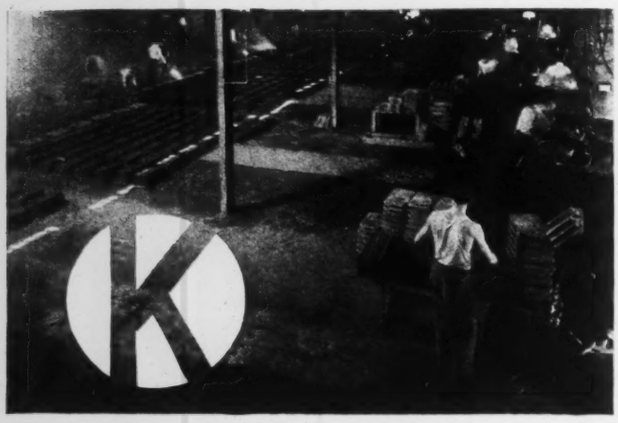

New Valve Operator and Damper Control Motor

No. 640—New high power valve operator, made for either high or low voltage operation, includes wick oiled motor, machine-cut heat treated gear train, with side plates, plunger, etc., of stainless steel. New oil-immersed damper control motor developed by the same manufacturer rated at 1000 lb in. torque makes use of a "Barcol Midget" motor, and is available for high or low voltage operation. The gear train of this unit consists of high grade machine cut gears and the entire assembly including motor, gears, limit switches, etc., runs in a bath of oil completely submerged. The unit is equipped with a speed governing device, externally adjustable, affording a speed variation of from 10 to 1. With standard gear set this affords 180 deg operating stroke, time varying from 95 to 950 seconds.—Barber-Colman Co., Rockford, Ill.

Leak Detector for Halide Refrigerant Gases

No. 641—New "Prest-O-Lite" halide leak detector for refrigerant gases consists of a regular needle valve torch handle assembly, a burner which includes a suction nipple for attaching a rubber hose, and a chimney with a copper reaction plate, has been developed to furnish a quick and sure method of locating leaks while cooling units are being installed or during servicing. To operate detector, flame is adjusted, and open end is used to explore around those places where a leak might occur. Color indication of a small concentration of refrigerant gas is given by green tinted flame; when a large amount of leakage is present, flame assumes intense violet color. After source of leak has been passed, flame clears quickly.—Linde Air Products Co., 30 E. 42nd St., New York, N. Y.

Humidistat, Thermostat Combined in New Control

No. 642—Two new instruments—the "Hytherstat" and the "Comfortrol"—combine the mechanism for complete control of air conditioning in one compact device 4½x7x1¾ in. The former is simply separate humidistat and thermostat mechanisms in a single case for use where it is wished to avoid fitting two separate controls. The "Comfortrol," on the other hand, has a temperature scale in degrees of effective temperature, and on it the setting dials are inter-geared to give control in terms of the *A.S.H.V.E.* comfort chart or in degrees effective temperature. If one steps down the relative humidity setting by means of the left hand dial, the dry bulb temperature setting is simultaneously changed in the proper ratio to maintain the effective temperature. A slipping clutch mechanism for the right hand setting dial permits raising the dry bulb or thermostatic point of control only while leaving the percentage relative humidity unchanged.—Julien P. Friez & Sons, Inc., Baltimore St. & Central Ave., Baltimore, Md.

Pillow Block Has Split Construction

No. 643—"SA Type" pillow block has a split construction to provide for the least number of parts, and, with the "SKF" spherical roller bearing, has inherent ability of rolling self-alignment without imposing extraneous loads due to setup inaccuracies or shaft deflections. Designed with cross and transverse ribbing to assure greatest strength with least weight and to minimize warping. Felt sealing rings shield bearings against dirt; when dirt conditions are extremely severe, flingers can be used.

To install, the lower half of the pillow block is set in place and bolted, the bearing mounted on the shaft and properly located. The upper half is then bolted on.—SKF Industries, Inc., Front St. & Erie Ave., Philadelphia, Pa.

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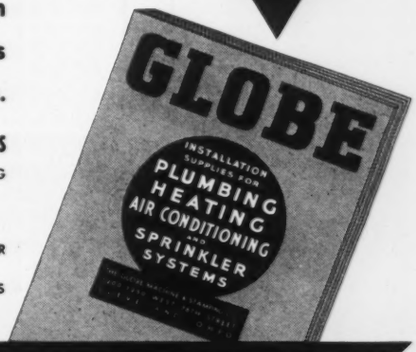

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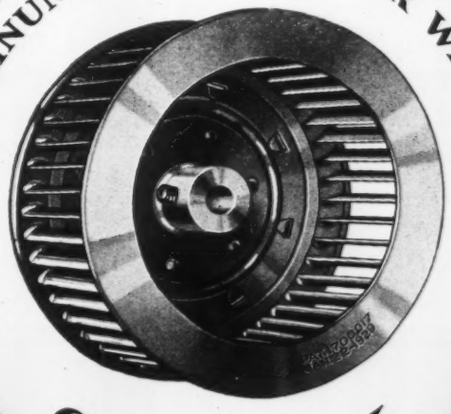

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Book Reviews

Metallic Arc Welding

"Metallic Arc Welding," by H. Harris, Ph.D., D.I.C., A.R.C.S. Published by Longmans, Green & Co., 114 Fifth Ave., New York, N. Y. London: Edward Arnold & Co. 1st edition, 1935. 197 *pp.,* 6x9 *in., clothbound. Price* $6.00.

It has been the author's object to summarize the present knowledge of the subject of arc welding, for the developments made within the last decade, though not widely appreciated, are of prime importance where new applications of the technique are considered. While major attention is given to the welding of mild steel, the welding of alloy steels and alloys has not been neglected where the necessary data were available.

The twenty-one chapters into which the subject matter is divided include the theory of the electric arc; the metallic arc welding process; the electrode; effect of metallic arc welding on the base metal; physical properties of weld metal; arc welding equipment; testing of welded products; influence of oxygen in steel and weld metal; ageing of weld metal; welding of structural alloy steels, austenitic chromium nickel steels, austenitic manganese steels, copper and its alloys, and nickel and monel metal; application of welding to the manufacture of pressure vessels and the chemical industry, boiler drums, pipe manufacture, and ship construction; and miscellaneous applications.

Booklets, Reports and Papers

Rating and Testing Condensing Units

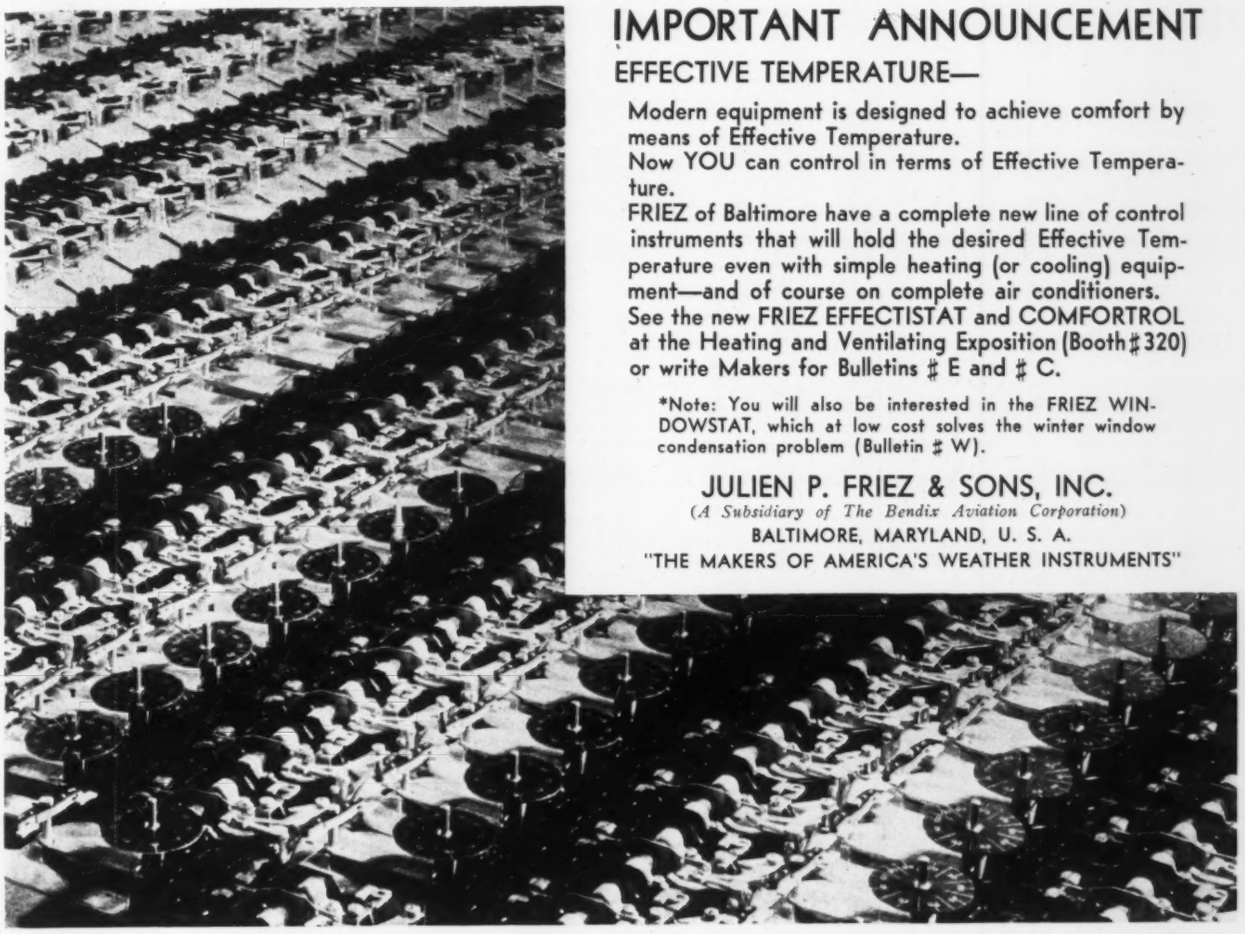
"Proposed Standard Method of Rating and Testing Mechanical Condensing Units," by the Joint Committee on Rating Commercial Refrigerating Equipment. Published by the American Society of Refrigerating Engineers, 37 W. 39th St., New York, N. Y. 14 *pp.,* 8½x11½ *in. .Price* 15c.

These standards represent several months of intensive work on the part of a joint committee composed of representatives of the *A.S.R.E.* (Glenn Muffly, F. R. Zumbro and W. R. Woolrich), the *Refrigerating Machinery Association* (L. S. Morse, A. H. Baer and W. H. Carrier), the refrigeration division of the *National Electrical Manufacturers Association* (H. M. Williams, L. A. Philipp and Chester Lichtenberg), the *Air Conditioning Manufacturers Association* (Donald E. French, L. S. Morse and H. M. Williams), and the *American Society of Heating and Ventilating Engineers* (W. A. Stark, F. H. Faust and C. W. Walton, Jr.). They are in approximately final form, although there may be one or two further revisions of a minor character, it is stated.

Four methods of testing and rating mechanical condensing units are proposed as optional, and definitions, equations and methods of procedure are explained in detail.

Selection of Coal for Underfeed Stokers

A paper on "Factors in the Selection of Coal for Underfeed Stokers" prepared by a committee of fuel engineers representing Appalachian Coals, Inc., and presented at the annual meeting of the *American Society of Mechanical Engineers,* 29 W. 39th St., New York, N. Y., December 2-6, calls attention to the complexity of the problem and describes what is being done to advance the state of the art. Present bases for coal selection are discussed, preparation of stoker coal described in some detail, and major attention given to what is thought to occur in an underfeed stoker fuel bed, characteristics of coal that influence its combustion, and design characteristics affecting combustion behavior.



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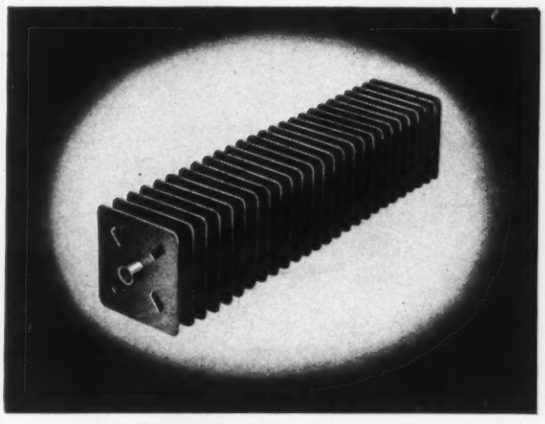

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Gas Industry Booklet on Testing Program

"For the Benefit of the American Gas Industry and 63 Million Gas Consumers," published by the American Gas Association, 420 Lexington Ave., New York, N. Y.; 1032 E. 62nd St., Cleveland, Ohio; or 718 Towne Ave., Los Angeles, Cal. 40 pp., 6¾x10 in.

This booklet was published recently in commemoration of the tenth anniversary of the *A.G.A.'s* testing laboratories program, and treats in readable style of this work, emphasizing in particular its value to the gas industry, manufacturing and contracting enterprises, and the public.

Organization and facilities of the laboratories are described, the work of the past decade is high-lighted, and plans for the future are briefly outlined.

The Editor's Correspondence

Control of Indirect Water Heaters

THE EDITOR—

In the June, 1935, H. P. & A. C. the article on page 289 advises locating the aquastat in the heater or in the pipes to the heater. In the November, 1935, issue, page 535, another writer recommends installing an aquastat in the manifold or top of the heater. The latter recommendation conforms to that of indirect water heater manufacturers.

As we are giving consideration to installing indirect heaters and as we have had no experience along this line, I shall appreciate your comments and recommendations.—L. O. A., Director, Buildings and Grounds.

Reply—The reader has noted and questions the seeming contradictions concerning the control of indirect water heaters, or year around heat transfer devices which circulate water from below the water line of a steam boiler, through or around a copper coil or similar device for heating service water.

A contemporary, writing principally about methods for tapping the necessary water circulating openings in sectional cast iron boilers in the November article mentioned, said rather incidentally "To maintain temperature in the steam boiler below the steaming point, it is necessary to install an aquastat in the manifold or top of indirect heater."

The present writer, replying in the June, 1935, H. P. & A. C. to a correspondent who was having difficulty in summer to obtain sufficient service hot water from a steam heating boiler, said "Hot water in the storage tank rather than only in the boiler header, is what is wanted in summer. Therefore the aquastat (which controls the fire intensity) should be placed in the middle of the side of the tank," etc.

The reader wishes to be told which of us is right, since he states that the recommendation to place the aquastat in the manifold or in the top of the heater conforms with the recommendations of indirect water heater manufacturers. This is to advise him that I am right and that I believe that my contemporary who said "aquastat in the manifold or top of indirect heater" would agree if he had given the matter particular instead of incidental attention.

The apparent conflict probably is due to the kind of control and kind of fuel. For instance, with manually fired coal in the boiler, the stored heat due to the fuel bed might heat the storage tank sufficiently after the aquastat placed in the manifold had shut-off the drafts; and might overheat the water in the storage tank if the thermostat were placed down at some point in the tank which indicated an average water temperature. Having developed this fact by experience of many years ago manufacturers simply have failed to modernize their data.

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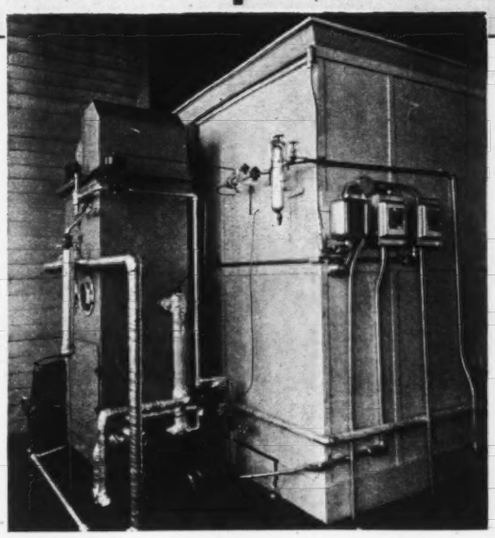

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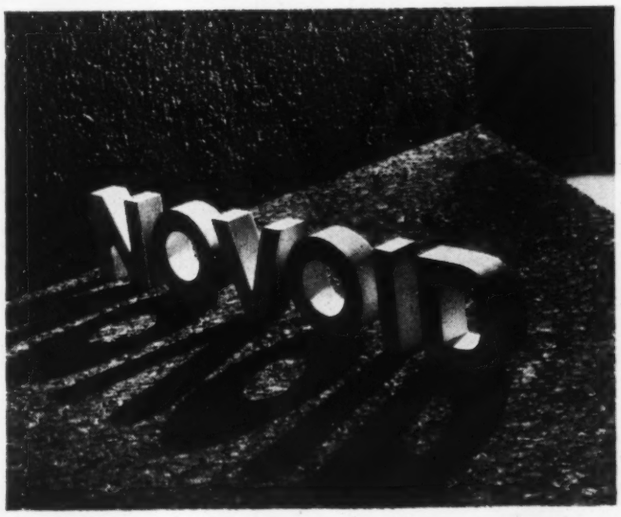

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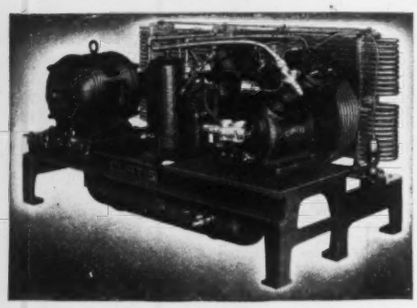

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automatic fuel burning devices such as oil burners and gas burners has demonstrated to my satisfaction repeatedly that there are no trouble calls because of insufficient hot water if the aquastat is placed in the average temperature zone of the tank, while with the top location there is no storage of hot water against a sudden demand, and the oil burner is operated jerkily in short, heart breaking cycles hunting continually to satisfy a rapidly fluctuating aquastat. The aquastat in the top must fluctuate due to cool water striking it whenever there is a heavy withdrawal of warm water.

It is not practical to adjust the top located aquastat so as to prevent this hunting by the automatic fuel burning device. However, with the center located aquastat the adjustment can be arranged so that reasonable accommodation to the heat storage characteristics of manually fired coal can be made.[1]—SAMUEL R. LEWIS.*

[1]This proposition was submitted to Mr. R. E. Weeks, an expert on hot water heaters and the Chicago representative of the Whitlock Coil Pipe Co., manufacturers of hot water heat transfer apparatus, who verified and endorsed it.

*Consulting Engineer, Chicago, Ill., Member of Board of Consulting and Contributing Editors.

Moisture Retained by Coal

THE EDITOR—

What is the maximum percentage of moisture which will be held by a ton of coal?—W. O.

Reply—The moisture which will be retained by a pile of coal if it is thoroughly wetted and allowed to drain will depend on a number of factors. The most important one is the size or mixture of sizes of the coal pieces; others are the kind of coal, as to whether some of the moisture is absorbed into the coal pieces or whether it all remains on the surface, the way the coal is piled and its ability to drain, and the period elapsing since the wetting. For an eastern bituminous coal immersed in water and allowed to drain freely, a 1x2 in. coal would retain 2 per cent surface moisture, and a minus 48 mesh dust 25 to 30 per cent. A minus 1 in. slack would retain from 7 to 8 per cent. The increase in moisture because of rainfall will depend on the depth of the pile, because most of the water will be retained near the surface and will evaporate more readily. Central and western coals contain more moisture when mined than do the eastern; some of this is lost by air-drying and if the coal is wetted it is able to absorb some of the water in addition to that which is retained on the surfaces.—P. NICHOLLS.*

*Supervising Engineer, Fuels Section, Bureau of Mines Experiment Station, Pittsburgh, Pa.

Conventions and Expositions

International Heating & Ventilating Exposition: January 27-31, International Amphitheater, Chicago, Ill. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

American Society of Heating and Ventilating Engineers: Annual meeting, January 27-31, Palmer House Hotel, Chicago, Ill. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

National Warm Air Heating and Air Conditioning Association: Winter meeting, January 27-29, Hotel Stevens, Chicago, Ill. Managing Director, A. W. Williams, A. I. U. Bldg., Columbus, Ohio.

Southern Industrial Show: April 6-11, Textile Hall, Greenville, S. C. Wm. G. Sirrine, President.

National Oil Burner Show: April 14-18, Convention Hall, Detroit, Mich. Managing Director, G. Harvey Porter, Oil Burner Institute, Inc., 30 Rockefeller Plaza, New York, N. Y.

Great Lakes Exposition: July-September, Exposition Hall, Cleveland, Ohio. General Chairman, Dudley S. Blossom, Terminal Tower, Cleveland, Ohio.

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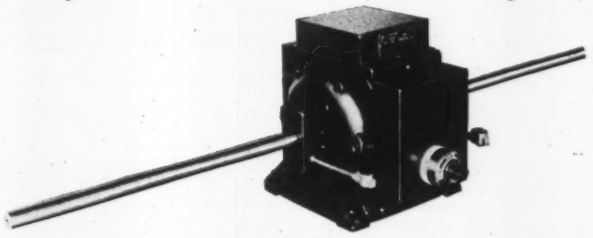

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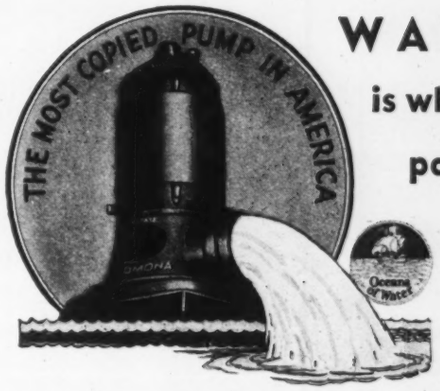

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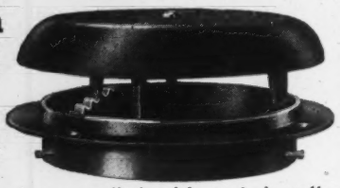

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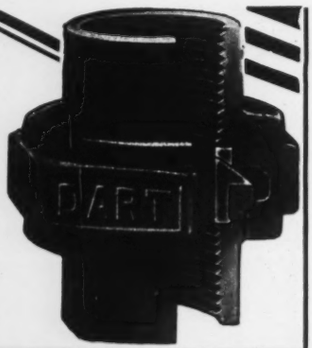

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Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 185.

No. 754. AIR ELIMINATORS: Gorton Heating Corp., Cranford, N. J. Aluminum plate showing actual sizes of air outlets of "Gorton" equalizing valves and air eliminators for one and two pipe steam and vapor heating systems.

No. 755. ALTERNATORS: Enterprise Foundry Corp., 2900 19th St., San Francisco, Cal. Data sheet describing electric alternators (and showing wiring) for intermittently alternating electrical circuits, such as two pump motors, magnetic valves, oil burners, etc.

No. 756. BEARINGS: SKF Industries, Inc., Front St. and Erie Ave., Philadelphia, Pa. 8 p. booklet explaining how "SKF" bearings can replace plain bearings on fans and blowers, giving types of fans, shaft diameters and other designations for 86 actual change-over jobs. Details and dimensions of fan bearings are given.

No. 757. BOILERS: American Radiator Co., 40 W. 40th St., New York, N. Y. 186 p. pocket size booklet giving ratings, dimensions and other data for "Ideal" boilers.

No. 758. COMPRESSORS: Carbondale Machine Corp., Harrison, N. J. 6 p. bulletin describing in detail horizontal duplex type single stage and two stage, belt driven or direct connected to synchronous motor, refrigerating compressors equipped with feather valves, giving features of construction, dimensions, etc.

No. 759. COMPRESSORS: Ingersoll-Rand Co., Phillipsburg, N. J. 36 p. bulletin describing power driven, horizontal duplex, double acting, cross-head type, moderate speed, heavy duty compressors in capacities ranging from 50 to 250 hp for single or multi-stage air or gas compression.

No. 760. CONTROL: Automatic Products Co., 121 N. Broadway, Milwaukee, Wis. 8 p. condensed catalog of control equipment, including thermostats; expansion valves; refrigerant, water, oil and gas control valves; transformers, relays and other devices.

No. 761. COOLING TOWERS: Research Corp., 405 Lexington Ave., New York, N. Y. Loose leaf bulletin giving detailed technical information on "Coey" cooling towers, including numerous diagrams, cost tables, performance charts, and describing the towers and their application.

No. 762. COPPER MOLYBDENUM IRON: Republic Steel Corp., Central Alloy District, Massillon, O. 12 p. folder on the properties of "Toncan" iron, with condensed information on physical properties and physical constants of this corrosion resisting alloy iron.

No. 763. DAMPER REGULATORS: Parker-Kalon Corp., 200 Varick St., New York, N. Y. New price list on dial damper regulators, damper quadrants and damper bearings.

No. 764. DRIVES: Worthington Pump & Machinery Corp., Harrison, N. J. 4 p. folder on V belt drives, giving width, thickness, pitch length, angle and list prices for this company's drives, and giving serial number comparison for those of other manufacture.

No. 765. DUST COLLECTORS: Pangborn Corp., Hagerstown, Md. Leaflet featuring dust collecting for blast cleaning rooms and describing this company's equipment briefly.

No. 766. ELECTRIC TOOLS: Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill. Catalog of high frequency electric tools, describing attachments for electric screw driving and nut setting, and giving illustrations and specifications for the entire "Thor" line of tools.

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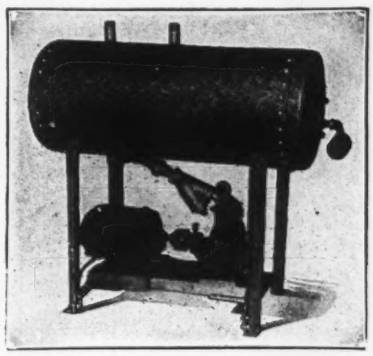

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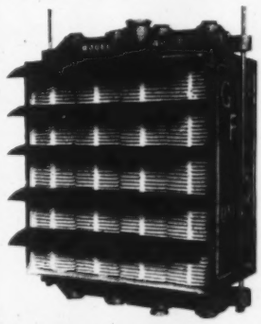

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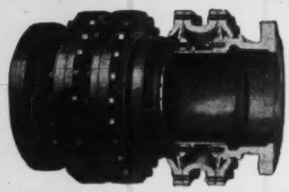

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No. 767. EXPANSION JOINTS: Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. 16 p. bulletin on "Yarway" expansion joints, giving complete information on features of construction, list prices, and tables of pertinent information.

No. 768. FANS: Autovent Fan & Blower Co., 1805 N. Kostner Ave., Chicago, Ill. 6 p. performance data and price sheet covering complete line of two different types of propeller fans and accessory equipment, including a fan with non-overloading power characteristic feature, and accessories.

No. 769. FITTINGS: Stanley G. Flagg & Co., Inc., 1421 Chestnut St., Philadelphia, Pa. 163 p. catalog of malleable iron, cast iron, and red brass fittings, giving complete information and list prices on the numerous items covered.

No. 770. GAGES: United States Gage Co., Sellersville, Pa. Catalog sheet describing and giving list prices for pressed steel or brass gages of various types.

No. 771. INSTRUMENTS: Practical Instrument Co., 2717 N. Ashland Ave., Chicago, Ill. Leaflet describing recording instruments for air temperature, relative humidity and electrical operation, with list prices and notes on applications.

No. 772. INSULATION: Silvercote Products, Inc., 161 East Erie St., Chicago, Ill. 16 p. circular giving general information, technical data and specifications for use in the application of "Silvercote" insulation fabric, insulation coreboard and insulation board in various forms of construction, showing many detailed drawings.

No. 773. NICKLE CLAD STEEL: Lukens Steel Co., Coatesville, Pa. 24 p. bulletin illustrating numerous applications of nickle clad steel for economical corrosion resistance, and giving information on the properties, fabrication, sizes, weights, etc., of nickle clad steel.

No. 774. OIL HEATERS: Griscom-Russell Co., 285 Madison Ave., New York, N. Y. 4 p. bulletin on storage tank oil heaters for heating viscous oil to be withdrawn from tanks, describing construction and features of the unit, and showing specifications and typical methods of installation.

No. 775. PIPE JOINTS: The U. S. Stoneware Co., Akron, O. 4 p. circular on "Flexlock" stoneware pipe joints, describing features of construction and giving dimensions, etc.

No. 776. PRESSURE REGULATORS: Mason-Neilan Regulator Co., 1190 Adams St., Boston, Mass. 40 p. catalog devoted to pressure regulators and control equipment, including reducing valves, pump pressure regulators, steam pump speed governors, balanced valves, hydraulic damper regulators and strainers, giving complete information on construction, advantages, uses, and including capacity tables.

No. 777. PUMPS: Worthington Pump & Machinery Corp., Harrison, N. J. 4 p. bulletin on horizontal duplex piston pumps, valve plate style, renewable liner type, for general service handling liquids at pressure up to 250 lb.

No. 778. RADIATORS: American Radiator Co., 40 W. 40th St., New York, N. Y. 64 p. pocket size catalog giving ratings, dimensions and data on radiators of various types, as well as "Vento" heaters and other equipment. Also, 44 p. pocket size

JUST A MINUTE!

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catalog of "Ideal Arco" accessories, including water heaters, regulators and controls, valves and various other items.

No. 779. RADIATOR VALVES: The Trane Co., La Crosse, Wis. 4 p. bulletin describing hermetic radiator valves and other items, giving detailed information on construction and list prices.

No. 780. RELAYS: Struthers Dunn, Inc., 139 N. Juniper St., Philadelphia, Pa. 28 p. catalog of relays, timing devices, thermostats and other electrical equipment.

No. 781. REGULATORS: Square D Co., Regulator Division, 6060 Rivard St., Detroit, Mich. Data sheets on pressure regulators with high pressure cutout for refrigeration, pressure and vacuum regulators and overload protection for these regulators.

No. 782. SHEAVES: Allis-Chalmers Mfg. Co., Milwaukee, Wis. 16 p. bulletin giving complete information on "Duro Brace Texsteel" sheaves for "Texrope" drives for stock V belt drives up to 15 hp, and including dimension tables, complete hp and center distance tables and price list tables.

No. 783. STEEL: Inland Steel Co., First National Bank Bldg., Chicago, Ill. 64 p. booklet entitled "Sizes We Roll," giving complete size data on sheets, strip, bars, plates, structural and semi-finished steel.

No. 784. SPEED REDUCERS: Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa. 32 p. catalog on single, double and triple reduction herringbone-gear speed reducers for large speed ratios, and heavy and shock loads.

No. 785. STEAM DISTRIBUTION EQUIPMENT: American District Steam Co., North Tonawanda, N. Y. Loose leaf catalog containing some 130 pages of engineering, dimensional and price data on complete "Adsco" line of expansion joints, meters, steam traps, pipe casing, water heaters, vapor heating specialties, and other steam distribution equipment.

No. 786. TURBINES: General Electric Co., Schenectady, N. Y. 16 p. booklet on steam turbines for mechanical drive of pumps, fans, compressors, blowers, pulverizers and paper machines, giving complete information on construction and showing photographs of a number of installations.

No. 787. WELDING: The Hobart Brothers Co., Troy, O. 40 p. pictorial booklet entitled "A Trip Through the Most Modern Arc Welder Factory in the World," describing the manufacture of this company's "Simplified" arc welders.

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